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PRESIDENT'S MESSAGE

D. G. Malcolm

Is Industrial Engineering a Fundamental Branch of Engineeering?

Historically it has been characteristic of the engineering profession to engage in the development of scientific knowledge and to apply this knowledge in the solution of man's problems. Review of the phenomenal growth of the engineering profession in America would seem to indicate that the problem areas of our society existing at a given time have played a most important role in the direction of this growth and also in the semantics employed in describing engineering accomplishments and organization.

Indeed, it is in this last statement, wherein lies one of the more perplexing problems of the engineering profession. Leaders in the engineering field are presently quite concerned over the many different names of "branches of engineering" which are appearing as curricula in our colleges and also as professional societies. The uncoordinated and uncontrolled growth in this regard is certainly capable of causing a "splintering" which will dilute the professional aspects of engineering and obscure the fundamental nature of the engineering approach.

One solution to this danger that has been suggested would concentrate further academic development of the engineering profession within the framework of what could be called the "fundamental branches of engineering" such as civil, mechanical, electrical, chemical, mining and metallurgical engineering.

Since there is much to be said in favor of such an approach, it is certainly appropriate to reflect seriously upon the question "Is Industrial Engineering a Fundamental Branch of Engineering?" While another important way, perhaps better, to look at this problem is to question the advisability of considering that there a r e *any* fundamental branches, these remarks will be confined to the question just raised.

Now, this is a much more difficult question to answer than it might appear

(Continued on Page 21)

THERBLIG RELATIONSHIPS: I.

Added Cycle Work and Context Therblig Effects

By Gerald Nadler, Ph.D.,
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and
Donald H. Denholm
Chief Industrial Engineer, Chase Bag Company, St. Louis, Mo.

One of the basic tenets of American industry is the divisions of work into components which can be performed with fewer and less specialized skills. A corollary tenet is the reduction of cycle time to take advantage of reduced training time necessary to reach top production. These tenets lead to eventual trouble in industry because the minimum operation would be the pick-up and disposal of parts. The problems lead to an attempt to reach an economical balance between reduced cycle benefits and parts handling duplication. From this problem comes a frequent question as to what effect an addition or elimination of an element of work will have on the other elements of the job. Many time study personnel have observed that an element remaining in a job, which has had an element added or removed, does not take the same amount of time as in the original job. Is this to be expected, or were the job elements unusual?

The past few years have seen this problem arise many times in relation to the predetermined motion-time systems (such as Work-Factor, MTM, MTA, etc.). These systems assign a "universal" time value to small qualitative units of work. These time values remain the same regardless of the length of the element or cycle.

Because of the fundamental nature of the problem, in both its theoretical and practical aspects, this study was undertaken. The purpose of this investigation was to determine the effect on the cycle time, when adding an element of work to the established cycle therblig times, and motion path of the original cycle.

EQUIPMENT

The sequence of motions took place between a start button, interruption button and selector switch. These were mounted on a flat work surface inclined 45 degrees to the horizontal. (See Figure 1). The selector switches were mounted 18 inches from the lower edge of the board. The start switch (an ordinary micro-switch) was mounted at the lower edge of the board. The interruption button was mounted mid-way between these two switches. All switches were in the same vertical plane. This plane passed through the center of the operator's position and perpendicular to the edge of the board.

Figure 1. Layout of experimental situation.

The interruption button was a circular door bell type of contact maker. It required a pressure of about six pounds to make contact.

All selector switches were of identical outward appearance. Each switch was turned clockwise through an angle of 30 degrees. The stop indication differed with each switch. Switch 1 stopped mechanically and would turn no further. Switch 2 indicated the 30 degree turn by an audible sound and feel as a roller dropped into a depression. Switch 3 had to be aligned at the 30 degree mark entirely by eye-hand coordination. All three switches required approximately the same amount of torque for turning.

Each operator sat on the same stool, 27 3/4 inches high. The operator's back was placed against the back rest and the stool moved so that the fingertips of the operator's outstretched right arm reached three inches past the center of the selector switch. The height of the microswitch was 37 1/2 inches above the floor.

A recording kymograph was connected to each of the switches. High speed movies (64 frames per second) were taken of each operator so that hand motions might be accurately plotted. The camera was a Kodak Special No. 2, using a 102 mm telescopic lens. The camera was located a specific distance (24'6") from the subject so that the hand pattern projection would be of the same scale for all operators. For the same reason, the camera was leveled and centered carefully on a constant reference mark on the work surface.

PROCEDURE

Five sophomore students of Washington University volunteered to serve as subjects. Each operator was told the purpose of the tests and thoroughly instructed in the two methods.

In the first method, the hand went from the start switch to the selector switch and back (Method A). The exact position of the hand during the "at switch" time was described and demonstrated. The operator was allowed to practice slowly for several cycles. Emphasis was placed on the proper and consistent placement of the hand for all conditions tested. When it became apparent that the operator knew the procedure, time trials were held. The results of the time trials are shown in Figure 2. Observing the times for the operator's trials soon gave evidence that the learning plateau was reached. These time trials were at the fastest pace the operator could maintain.

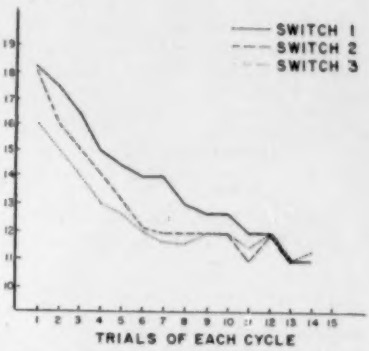


Figure 2. Illustration of training curves, Part A (without interruption).

The procedure was duplicated for Method B, with interruption button. Verbal and visual instructions were given as before. Particular care was given to this phase, since the introduction of the interruption button slowed the operator. Training curves were kept on each operator as illustrated by Figure 3. When the training times indicated that the learning plateau had been reached, the recording began.

The recording was made after the operator had started the cycle repetition. At the start of each test run, the operator was urged to go as fast as he could. Verbal incentives were provided throughout the trials to keep the pace at maximum. To further assure cycles being unaffected by additional familiarity or training, each condition of the switches and methods were tested twice in reverse order. The order in which the cycles were performed was as follows: 1A, 2A, 3A, 2B, 1B; 1B, 2B, 3B, 3A, 2A, 1A. Five cycles from each test run, a total of ten cycles for each switch and method condition, were used to assemble the data.

ANALYSIS OF DATA

The data were analyzed by analysis of variance, permitting comparisons of

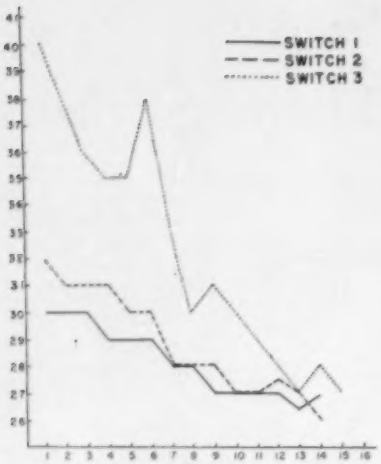


Figure 3. Illustration of training curves, Part B (with interruption).

two or more factors in all combinations.[1]

This procedure was used both for analysis of therblig times and the hand pattern areas and lengths. Analysis of variance indicates the statistical significance of difference of the times among the variables tested, in this case, among the three selector switches and between Method A (uninterrupted cycle) and Method B (interrupted cycle with the interruption subtracted out). It is possible to perform these calculations for various combinations of therbligs as well as for the cycle itself. The analysis was made for:

a. Total cycle time (entire element)
b. Movement time only (TE_a+G+RL+TE_d)
c. At start switch time (contact time)
d. To selector switch (TE_a+G)
e. Turn selector switch
f. To start switch (RL+TE_d)

Analysis of variance yields a ratio referred to as the "F" value. These "F" values are tabulated[2] for the proper degrees of freedom with two values for each combination of degrees of freedom. A calculated "F" value larger than the upper number in each pair indicates that the obtained differences would have occurred less than 5 times out of 100, by chance alone. An obtained "F" value greater than the bottom number in each pair, indicates that the obtained differences would have occurred less than one time out of 100, through chance alone.

The hand patterns from the motion pictures were obtained by fixing the projector in a permanent location. The path of the hand was plotted by turning the projector one frame at a time for the five cycles filmed and marking with a dot the position of the hand as indicated by the black tape stuck to the hand prior to filming.

The hand patterns (average of the five subjects' hand pattern) indicate the difference in shape, length and area covered. (See Figure 4 for illustration of one switch). The average distance moved and vertical area covered by the hand are listed in Table 1. Since the vertical height of the hand above the table adds to the hand pattern variation, the area under the curve of the motion path was determined. Area might be considered here as an indicator of energy expenditure relationships since it is a two-dimensional measure. The lengths were measured from each individual curve by means of a pair of dividers (one-sixteenth of an inch). The area was determined by planimeter readings.

It is interesting to note that the more complex the task, the less the hand rose above the work surface. Conversely, the simpler the task the more exaggerated the motion.

RESULTS

The bar chart in Figure 5 gives a visual summary of the results.

(5) A change in work conditions of one therblig significantly affects the context therbligs.[3]

(6) A change in work conditions of one therblig significantly affects the length of the hand movement.

(7) The length of the hand movement is significantly different for reaching for and returning from selector switch, for different methods and for different switches.

(8) The area under the path of the hand movement is significantly different for different switches and for reaching for and returning from the selector switch.

Practically, these conclusions might be stated:

(1) Dissection of motions and the assignment of standard time values to these basic motions does not seem to be warranted.

(2) The use of existing tables of predetermined motion times can easily lead to large significant error.

(3) The use of standard data (tabulation of elemental time through accumulation of data by time study) may lead to significant error in the total time. However, the results indicate that the error of standard data is of much less magnitude than accumulation of times for individual therbligs or basic motions.

(4) The supposedly easy task of measuring distance cannot be done accurately or consistently. Although it is simple to conclude that the change in actual distance moved for the same linear distance caused the significant time differences obtained, the virtual impossibility of determining the correct distance on the job remains as an important deterrent to any predetermined motion-time system.

(5) As the number of therbligs in an element or cycle increase, certain individual therbligs (TE, G RL) tend to increase in time. At the same time, other therbligs (turn) do *not* increase in time. This represents another of the reasons why the predetermined motion-time systems do not provide accurate or consistent time values for their basic motions. Even if they did, this conclusion shows the reason why the application of the values could not result in accurate and consistent standards.

Although the experimental results verify trends observed in industry, there is much work to be done in the area of determining optimum cycle length.

(Continued on Page 23)

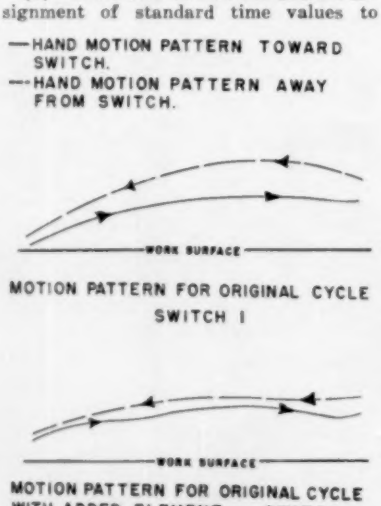
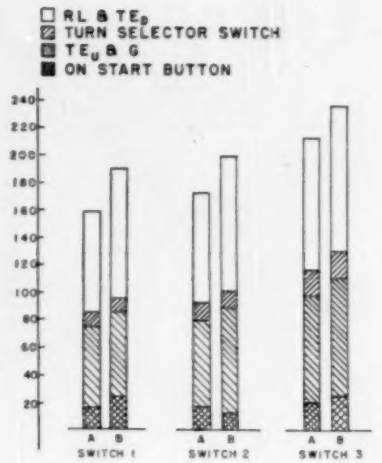

—HAND MOTION PATTERN TOWARD SWITCH.
---HAND MOTION PATTERN AWAY FROM SWITCH.
WORK SURFACE
MOTION PATTERN FOR ORIGINAL CYCLE
SWITCH 1
WORK SURFACE
MOTION PATTERN FOR ORIGINAL CYCLE
WITH ADDED ELEMENT— SWITCH 1

Figure 4. Average hand motion pattern for original cycle and for original cycle with added element.



	Switch 1		Switch 2		Switch 3	
RL & TE_d	74.6	93.4	81.5	98.0	98.0	103.0
Turn Selector Switch	9.8	11.0	12.6	12.5	20.2	21.6
TE_a & G	59.4	62.4	63.0	75.6	76.2	84.4
On Start Button	14.8	22.8	16.0	12.5	21.0	26.6
TOTAL	158.6	189.6	173.1	198.6	215.4	235.6

Figure 5. Comparison of Method A (Cycle Time) and Method B (Interrupted Cycle Time Less Interruption Time).

[1]Lindquist, E. F. "Statistical Analysis in Educational Research," Houghton Mifflin, New York, 1940.

[2]Lindquist, E. F., ibid.

CURRENT JOB DESIGN CRITERIA

By

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In an earlier article on job design,[1] it was indicated that, in spite of all the research investigations of various aspects of jobs, such as job satisfaction, etc., so far there have been no principles formulated which can assist industry in organizing and assigning work to separate jobs. It was further asserted that designing jobs (i.e., determining what the work content of the various jobs should be) is an important phase of the manufacturing planning process. Also, job design was emphasized as probably being an important variable affecting productivity. A potentially valuable criterion was suggested for assessing the effectiveness of a given job design, mainly involving the extent to which the design of a job reduces total cost to produce rather than minimizes immediate or direct cost.

In general terms, the job design process can be divided into three activities: (1) the specification of the content of individual tasks, (2) the specification of the method of performing each task, and (3) the combination of individual tasks into specific jobs. The first and third activities determine the content of the job, while the second indicates how the job is to be performed. It is possible therefore to speak about the design of job content and the design of job methods.

Considerable detailed study has taken place and a large body of knowledge exists concerning the design of job methods, so much so that a specialized professional branch of industrial engineering called methods engineering has become devoted to it.[2] On the other hand relatively little information has been available concerning the design of job content.[3] For the purpose of our research program and to maintain some semantic agreement, we refer to the process of designing of job content as job design and that of the design of job methods as methods design.

Although sufficient data are lacking to make a conclusive statement, there appears to be a relationship between job content and productivity, quality, employee turnover, and other measures of effective work organization. Furthermore, at present there is not enough information in an integrated form to postulate a practical theory of job design.

Individuals undertaking the design of industrial jobs usually do so with certain criteria in mind, whether or not these are explicitly stated. There are strong indications at present that the apparent criterion of minimizing immediate costs implemented by the principles of minimizing skills, minimizing direct unit operation time, and maximizing specialization is not giving satisfactory results in terms of total costs of producing. As indicated previously, we suggest that job design principles should be based on the criterion of minimizing total costs, rather than of minimizing immediate or direct costs. The technical requirements for achieving production have been carefully studied and specified. However, many factors known to affect performance have never been fully evaluated as possible principles for the design of jobs, and of course, a unified theory of job design has never been developed.

The study reported in this paper was undertaken on the assumption that underlying principles for job assignment or job design (or whatever kind) do in fact exist and are in use. The purpose of the study was to bring them to light. We wanted to obtain information regarding the manner in which American industry designs jobs as to their content. It was proposed to carry out the purpose by investigating:

1. The decisions made in the process of designing jobs.
2. The precepts, principles, intuitions and other guides or referents used in the making of these decisions.

To investigate the decisions made and the referents used in job design, a list of general questions about the design process was developed. These formed the basis for a survey of current job design methods and criteria in American industry, carried out by means of interviews and mail questionnaires. The questions were:

1. Where does job design enter into the production planning procedure? Does this occur at any particular stage in the planning procedure, such as before or after the production process is chosen, or before or after the individual operations making up the production process are chosen, or does job design take place at all stages of planning?
2. What are the factors considered in making a choice between various alternative methods available for performing required operations?
3. What criteria are used to specify the content of individual tasks and to combine these tasks into jobs? Are there any systematic methods for doing this?
4. Who in terms of position held in the company performs the job design functions?
5. How much control does the designer of jobs have over the content of various types of jobs?
6. Are there any methods for determining the effectiveness of job designs?
7. Is there any indication that job content effects productivity, employee turnover, or quality?
8. Are there any variations in job design methods, specific to different industries?

Detailed questions were developed from these general questions and used in the survey. The actual questions asked in the survey were of two types. First, questions pertaining to specific cases of job design and second, questions concerned with job design procedures in general. The interviews and questionnaires were divided into ten sections which dealt with the following subjects:

1. Identification of characteristics of the respondent companies
2. Definition of terminology
3. Approximate percentage of the total number of production workers in various major types of work
4. Procedures employed and decisions made in setting up new operations or in revising existing operations
5. Degree of standardization of individual tasks within the company
6. General procedures employed in combining individual tasks into specific jobs
7. Factors imposing restrictions on the assignment of tasks to individuals
8. Policies used in dealing with problems concerning productivity, employee turnover, quality and employee transfers
9. Persons performing the job design function within the company
10. Experience concerning the effect of job content on productivity

Method of Investigation

The survey of job design practices as currently carried out in American

[1]Davis, L. E., and Canter, R. R., "Job Design," **Journal of Industrial Engineering**, Vol. 6, No. 1, Jan., 1955, p. 3.

[2]Davis, L. E., "Work Methods Design and Work Simplification," **Progress in Food Research**, Vol. IV, ed., E. M. Mrak, and G. F. Stewart, 1953, p. 37, Academic Press, N.Y.

[3]Walker, C. R., "Work Methods, Working Conditions and Morale," **Industrial Conflict**, ed., A. Kornhauser, R. Dubin, A. M. Ross, 1954, p. 215, McGraw Hill Book Co., N.Y.

industry was conducted using both personal interviews and mail questionnaires. The investigation was limited to industrial jobs of low or moderate skill requirements which included such typical industrial jobs as those in assembly, packing, inspection, and fabrication. Clerical jobs and supervisory jobs such as those of managers and foremen were excluded from investigation.

Findings

The findings are based upon seven interviews with manufacturing firms and upon the analysis of the returns of 490 questionnaires sent to a selected sample of U.S. industrial companies. The sample was limited to larger organizations with capital value being used as a gauge of company size. In all a total of 12% of the companies responded to the questionnaire. Twenty-four of the 490 completed the questionnaire and 35 indicated that for various reasons they could not participate. It may be inferred from this response that American industry is not concerned to any great extent with work organization or job design. Although the sample is quite small, and the industries diverse, the responses obtained are highly consistent. The findings are additionally significant if we further consider that the responses probably come from organizations having an interest in work organization or job design.

Interview Findings

The findings in the interviews are reported separately from those in the questionnaire largely because the former are taken from non-directed responses to open-ended questions. In the interviews all of the companies were asked what factors they normally take into consideration in assigning tasks to workers and in combining the tasks to make specific jobs. All of the companies considered it very important to:

1. Break the job into the smallest components possible to reduce skill requirements.
2. Make the content of the job as repetitive as possible.
3. Minimize internal transportation and handling time.
4. Provide suitable working conditions.
5. Obtain greater specialization.
6. Stabilize production and reduce job shifts to a minimum.
7. Have engineering departments, whenever possible, take an active part in assigning tasks and jobs. (In all the companies the line foreman or supervisor was directly involved in carrying out these activities.)

Questionnaire Findings

The responding companies varied in numbers of employees from 97 to 14,000. The majority of the production workers in 15 of the 24 companies were machine operators or assembly workers. As indicated above, the questionnaire was divided into ten sections and posed questions pertaining to both specific cases of job design and job design procedures in general. The answers to the questions should provide us with an understanding of the decisions made in designing jobs and of the referents for these decisions.

The first question asked where does job design enter into the manufacturing planning procedure. The interviews indicated that planning for manufacture is carried out in the following sequence of steps:

1. The overall manufacturing process is planned.
2. The process is subdivided into operations according to various criteria.
3. The operations are subdivided into elements.
4. The elements are organized into specific tasks.
5. The specific tasks are combined into individual jobs.

In all of the specific cases reported in interviews and questionnaires the problems of work organization were centered around the planning of the individual operations making up the production process. Considerations as to the content of the tasks to be assigned to individual workers had some effect on the choice of methods for performing the operations. While it is entirely possible that the planning of an entire production process could be based on considerations of job content it is probably satisfactory to generalize that the process of job design is centered around the phase of the manufacturing planning procedure concerned with planning of separate operations.

The second question asked what are the factors considered in making a choice between various alternative methods available for performing required operations. Table 1 gives the factors ranked in order of importance taking into account both number of mentions and weight of ratings assigned that were considered in choosing methods for performing twenty-four specific operations. While these factors pertain to specific operations and their order of importance may change with various situations, they provide an indication of the different kinds of factors that are considered.

Question three asked what criteria are used to specify the content of individual tasks and to combine these tasks into jobs. To answer this question we need to examine:

1. The considerations governing the division of operations between workers.
2. The criteria used to specify the content of tasks.
3. The criteria used to combine tasks into jobs.

Table 2 provides the considerations which governed the division of operations between workers. In addition, as expected, companies used both the parallel method of work assignment, i.e., assigning the same operation to a number of workers, and the sequential method whereby operations are divided in sequence among workers. The reasons given as underlying the choice of specific methods for the division of operations are given in Table 3. In the cases reported, there seems to be no relation between the reasons given for the use of particular methods and the resulting methods used. In the majority of the cases several reasons were given to explain a choice made. Again, while the reasons apply to specific cases only, they do give an indica-

TABLE 1

MAJOR CONSIDERATIONS IN CHOICE OF PARTICULAR METHODS FOR PERFORMING OPERATIONS

Based on 24 Operations

	Major considerations ranked in order of weighted aggregate rating	Total number times mentioned order of importance from high to low 5	4	3	2	1	Weighted Aggregate Rating
a.	Minimizing time required to perform operation	14	4	1	—	—	89
b.	Obtaining highest quality possible	4	6	1	3	—	53
c.	Minimizing skill requirements of operation	1	3	4	3	4	39
d.	Utilization of equipment or tools presently on hand	1	4	2	—	—	27
e.	Minimizing floor space requirements	2	2	1	1	—	23
f.	Achieving specialization of skills	—	1	4	1	1	19
g.	Minimizing learning time or training	—	—	4	—	1	13
h.	Minimizing materials handling costs	1	—	—	2	1	10
i.	Equalizing and developing full work load for work crew members	—	1	1	1	—	9
j.	Providing operator satisfaction	—	1	1	1	—	9
k.	Minimizing equipment or tool costs	—	1	—	1	1	7
l.	Controlling materials used in operation	—	—	1	2	—	7
m.	Providing maximum production flexibility	—	1	1	—	—	7
n.	Simplifying supervision of operation	—	—	—	—	3	3
o.	Providing maximum safety in operation	—	—	—	1	1	3

tion as to the basis for the division of operations between several employees.

An examination of the considerations governing the division of operations between workers and of the reasons underlying the choice of specific methods of division provide us with the criteria used for the specification of the content of tasks. From this we may infer that the following are the criteria used in industry to specify the content of individual tasks. The content of tasks is specified:

1. So as to achieve specialization of skills.
2. So as to minimize skill requirements.
3. So as to minimize learning time or operator training time.
4. So as to equalize and permit assignment of a full work load.
5. In a manner which provides operator satisfaction. (No specific criteria for job satisfaction were found in use.)
6. As dictated by considerations of layout of equipment or facilities.

To determine the criteria for job design there still remains the need to examine the criteria governing the combination of tasks into jobs. Table 4 reports the general policies in use. The three methods most frequently employed to combine tasks into specific jobs are:

1. Assign each employee a specific operation as a full-time job.
2. Assign each employee a specific group of elements of an operation as a full-time job.
3. Assign each employee one particular element of an operation as a full-time job.

General comments indicated that the majority of companies believed in limiting the content of the individual jobs as much as possible. This means limiting the number of tasks within the jobs and limiting the variations permitted in tasks or jobs. This further indicates that specialization of work was a primary consideration. Another indication of this was obtained in the last section of the questionnaire which asked the respondents to report any indications they might hold concerning the relationship between job content and productivity. The pertinent comments made in this section are summarized as follows:

1. Tasks with too many elements of work reduce productivity.
2. Combining elements provides individual responsibility for those elements which usually improve quality and productivity.
3. Productivity is improved by revising tooling to reduce the possibility of errors and to reduce fatigue.
4. The greater the number of tasks assigned to an individual, the longer the training time required, and the lower the output. In general productivity will remain low.
5. Experience has indicated that job content does not appreciably affect productivity.
6. Job content is not as important as employee attitude. Mental attitude is the most important consideration. ". . . We specify job content to fit our facilities—then sell it."
7. Productivity was found to be higher when job content involved horizontal assignments (all elements at approximately the same skill levels).
8. Best results have been obtained by combining relatively few tasks into jobs for average workers. Overspecialization has not proved effective. Workers who show high aptitude and desire for diversified work are transferred to jobs in repair, or special products departments.
9. Simpler jobs result in higher output and make the workers happier. The company believes in simplification and elimination of rotation for job satisfaction.
10. In general, the greater the degree of specialization, the higher the productivity. When specialization becomes so refined that the job becomes unbearably monotonous, productivity tends to decline; however, the monotony and decline in productivity are off-set to some extent by the ever-

TABLE 2
METHODS FOR DIVIDING OPERATIONS BETWEEN TWO OR MORE EMPLOYEES
Based on 17 Operations

Methods for dividing operations	Per cent of Instances Used*
a. Each employee is assigned one particular element of the operation as a full-time job	5.9
b. Each employee is assigned a specific group of elements of the operation as a full-time job	41.1**
c. Employees assigned to the operation are allowed to divide the individual tasks in the operation among themselves informally	5.9
d. Each employee is assigned all the elements required to complete the entire operation	47.0***
e. Each employee is assigned a specific group of elements of the operation, but in cases of emergency or to provide themselves with training for promotion employees may voluntarily rotate or overlap in performance of assigned tasks	17.6****

*In this and in following tables percentages will total more than 100 percent because some respondents gave more than one response.
**In one case each employee was originally assigned a specific group of elements, but after receiving training was assigned all the elements required to complete the entire operation.
***In two cases operators are assigned groups of elements and permitted to rotate within limitations of job description as to equipment, etc.
****In one case operation totaled among several employees to equalize good and bad jobs.

TABLE 3
REASONS DICTATING CHOICE OF METHODS FOR DIVIDING OPERATIONS
Based on 17 Operations

Reasons dictating choice	Percent of instances reason given for choice of methods in Table 2				
	a	b	c	d	e
a. Certain phases of the operation required higher skilled workers than other phases	5.9	11.8	—	—	5.9
b. Workers with different skills were required for certain phases of the operation	—	—	5.9	—	5.9
c. Operation was machine paced and was divided in such a manner as to provide maximum utilization of machines	—	11.8	—	—	—
d. Layout of equipment or facilities needed for the operation dictated this division of tasks	—	23.5	—	11.8	5.9
e. Task of each individual was made as specialized as was practical	5.9	5.9	—	11.8	5.9
f. Operation is such that certain groups of elements must be performed at one workplace	—	11.8	5.9	11.8	5.9
g. Operation was divided in the manner suggested by the workers	—	—	5.9	—	—
h. Operation was divided to permit workers to inspect their own work and correct if necessary	—	5.9	—	—	—
i. Operation was divided to equalize distribution of work load	—	5.9	—	5.9	5.9
j. Operation is not divided at present	—	—	—	5.9	5.9*
k. Permit rotation of good and bad jobs	—	—	—	5.9	—

*Permit flexibility of movement within job grades

present challenge of the incentive system.

11. A change to an assembly line increases productivity.

In regard to systematic procedures for the design of jobs, i.e., specifying the content of tasks or combining tasks into jobs, none were reported in use in the companies surveyed.

Question four asked, who in terms of position held in the company performs the job design function. Table 5 provides this information. The findings show that line foreman had a part in specifying the content of tasks in all instances, and in all but a few instances he also took part in combining individual tasks into jobs.

Question five asked, how much control does the designer of jobs have over the contents of various types of jobs. Tables 6 and 7 provide information concerning this. The respondents indicated that in general, training requirements controlled work assignment or restricted job design to the greatest degree. Where they existed, union agreements definitely imposed restrictions on work assignment. In addition, union agreements placed some restrictions on work that could be assigned to jobs in each established job classification.

Question six asked, are there any methods for determining the effectiveness of a job design. Attempts to determine what methods were used to evaluate the effectiveness of job designs proved so fruitless in the interviews that the question was not pursued in the questionnaire. In the interviews persons questioned about tests of effectiveness of job designs replied that all production jobs are kept under surveillance by engineeering departments.

Question seven asked, are there any indications that job content has an effect on productivity, quality or employee turnover. The respondents were asked to describe the actions they had taken, or favored taking, to solve problems of low productivity, poor quality, high employee turnover, and excessive numbers of transfer requests. The remedies most frequently applied to problems of productivity were revision of methods, equipment, or product design, financial incentive programs, additional operator training, and employee indoctrination and educational programs. The remedies for problems of quality were revision in methods, equipment, or product design, disciplining of operators responsible for poor quality, additional training, statistical quality control programs, more inspection and more pressure on supervisors. The most frequent remedies applied to problems of turnover or transfers were improvement of working conditions, increased pay rates, and improved selection of personnel.

None of the companies reported considering alteration in job content as a possible remedy for any of these problems. A review of the literature indicates that in a number of instances benefits are being obtained by alterations in job content. In view of this it would be worthwhile to speculate why no action of this kind had been considered by any of the responding organizations. It is possible that the participating companies had neither the degree of standardization of operations nor the degree of specialization of jobs necessary so that the effects of alterations in job content could be observed or measured.

Question eight asked, are there any variations in job design methods in different industries. The small response to the questionnaire precludes any industry to industry comparison. Thus no relationship between particular processes and products, and job design practices can be given from the survey results.

TABLE 4
GENERAL POLICIES USED IN COMBINING TASKS INTO JOBS
Based on 24 Companies

Policies	Percent of Instances Policies Were Used for Job Types Indicated		
	All	Assembly	Machine Operation
a. Assign each employee one particular element of an operation as a full-time job	8.3	16.9	8.3
b. Assign each employee one particular element of an operation and rotate employees at intervals to other elements of the operation	12.5	8.3	—
c. Assign each employee one particular element of an operation as a full-time job and encourage employees to rotate jobs informally if they wish	4.2	4.2	4.2
d. Assign each employee a specific group of elements of an operation as a full-time job	12.5	20.8	33.5
e. Assign each employee a specific operation as a full-time job	25.0	16.7	29.2*
f. Assign groups of employees to specific groups of elements or operations allowing the members of the groups to divide the individual tasks between themselves informally	—	4.2	4.2
g. Assign each employee as his job all of the operations required to complete a process or product	—	16.7	4.2

*In one instance—applies to toolsetters

TABLE 5
RESPONSIBILITY FOR JOB DESIGN
Based on 24 Companies

Responsibility of	Per cent of Instances Specifies Content of Individual Tasks			Combines Separate Tasks Into Specific Jobs		
	Always	Sometimes	Never	Always	Sometimes	Never
a. Line foreman	25.0	66.7	—	25.0	58.3	16.7
b. Engineering department*	25.0	58.3	—	20.8	50.0	8.3
c. Personnel department	—	20.8	71.0	4.2	25.0	62.5
d. Plans Superintendent	—	4.2	—	—	4.2	—
e. Department superintendent	4.2	—	—	4.2	—	—
f. Committee consisting of foreman, scheduling supt., tool room foreman, and factory supt.	—	4.2	—	—	—	—
g. Production planning	—	4.2	—	—	—	4.2

*Including industrial engineering dept.

Summary and Interpretation of Findings

In the survey reported here, we have been concerned with learning how American industrial concerns design jobs as to their content. Job design is the name we have given to the process of designing job content. The process is carried out by specifying the content of tasks and by combining individual tasks into specific jobs. To learn how job design was being carried out it was necessary to examine, in addition to the design process itself, the decisions made in the process of designing jobs and the precepts, principles, and other guides or referents used in making these decisions. The findings of the survey may be briefly summarized as follows:

1. The job design process is centered around the phase of the manufacturing planning procedures concerned with the planning of separate operations.
2. In all instances the line foreman has a part in specifying the content of tasks and in all but a small number of instances he also takes part in

(Continued on Page 21)

A New Slant on Performance Rating

By Walter A. Mattheiss,

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Much has been written to assist the embryo timestudy engineer, except on the subject of performance rating. This most important subject has been left to explanation by example through personal contact with an experienced engineer, and more recently through the use of films establishing a national standard of performance. Although these methods have proven reasonably successful, they have fallen far short of a desirable success since they cover only one phase of industrial activity, namely the highly repetitive operation. It is in the projection of the same technique to other phases of industrial activity that problems arise, and for good reason.

Most of the highly repetitive operations have the following characteristics in common:

1. Motions are fast and rhythmic.
2. Reasonable perfection in performance permits the premise that variations in elemental times reflect inverse variations in performance.
3. Elements are generally of very short duration.
4. Even slight deviations from the regular pattern of motions can be readily recognized.

All of these characteristics lend themselves to objective study, in which the productive effort can be evaluated by the tempo of performance.

Thus, learning performance rating by the trial and error method, using repetitive operations as the testing pattern, works out fairly well, but the net result is an engineer qualified to study only repetitive operations. Less repetitive operations are another story. They contain more varied motions which distort the tempo and show less rhythmic action. Legitimate variations may occur in the conditions of the operation, producing legitimate variations in the elemental times, thereby voiding the premise that variations in the elemental times reflect variations in the performance. Elements may of necessity be of longer duration because of the spacing of clear-cut end points; and deviations from the regular pattern of motions become more difficult to recognize. Thus all of the props are knocked out from under the engineer's experience.

In the absence of any supplementary training, each engineer is on his own. Those with inherent abilities for observation and detail, manage to overcome the inadequate training, adjusting and improvising techniques to meet each situation. The majority have to stumble along trying faithfully, yet futilely, to project a technique that is not applicable to the new fields of operation. It is no wonder that many engineers fail to maintain any degree of consistency in results.

Sufficient success has been achieved with performance rating to justify its continued use. The need is to expand the training and development of engineers to cover a wider range of industrial operations. The generally accepted training procedures of today are inadequate to meet this need. To substantiate this statement, let us review the currently accepted training practices.

The trainee is instructed to rate the operation objectively, evaluating the performance by the tempo of the operation. This type of rating requires automatic elimination of high readings as representing either low performance or change in method. This is dangerous practice, as there is no provision for coping with legitimate variations in the elemental time. Can you imagine any big league umpire arbitrarily concluding that any pitch not swung at by the batter is a ball? No more so should high readings be automatically disqualified without specific reason. Furthermore, any technique that stresses a fine breakdown of the operation mainly because short readings more readily reflect variations in time, results in an analysis of readings rather than an analysis of the operation. On this basis, any establishment of an allowable range of variation can be nothing more than an arbitrary conclusion. These conclusions are too frequently presented as irrefutable fact. This is most unscientific.

What has the embryo engineer had to learn in order to qualify as a timestudy engineer?

Judging from the most widely used training practices, the essential requisite is to develop a mental picture of normal performance, applicable to any operation that is measurable. To the uninitiated this may sound plausible enough, but let us analyze this monumental task.

To retain any action picture in the mind with closed eyes is difficult enough. To retain an action picture in the mind while observing an entirely different group of motions is fantastic and impossible. Perhaps my interpretation of a mental picture is too literal. A more feasible interpretation would be that the mind retain not the action picture but the tempo of the action. This tempo is compared with the tempo of any observed operation.

Tempo as a basis for rating performance rests on a succession of unfounded premises. It is obvious that one tempo must serve as the norm for all operations. This conclusion is acceptable on the premise that speed is the only factor that is rated, which in turn is acceptable on the premise that speed is a constant, measurable factor, irrespective of the amount of effort, the sequence of motions, visual strains, the need of delicate handling, or stringent job specifications. Any break in the chain of premises causes a collapse of the technique of rating performance by tempo.

The teaching of performance rating has been over-simplified to the extent that a kindergarten technique is being used to teach a very complicated subject. It is not just a case of one tempo or many tempos. The whole concept is too vague and elusive for absorption by the embryo engineer. The tempo of any given operation can be readily memorized so that variations in the performance of that operation can be accurately evaluated. However, in order to use the tempo of one operation as a basis for evaluating another operation, it is necessary to analyze the tangible factors that produce a specific performance, in order that the same factors or comparable factors may be recognized in other operations. I have not encountered any training program in which this is done. In fact, objective study precludes the possibility of such an analysis; hence, the training procedure becomes its own stumbling block to successful application.

The embryo engineer, approaching his training with ambition to succeed, dares not admit confusion or inability to understand. He can only reason that others have succeeded before him, therefore to admit failure is to admit incompetence. The Union engineer approaching performance rating with skepticism and suspicion, learns enough about the elusive norm to justify his skepticism and verify his suspicions. If its rejection were only from organized labor, the contention of biased viewpoint might have credence. It is no secret that many Industrial Engineers in the field of timestudy disdain the use of performance rating as too inconsistent and unreliable.

What a paradox: *a profession dedicated to efficient management, unable to justify the basis of its most important tool!* Perhaps I paint too black a picture, or even give the impression that performance rating as a tool is impractical. The fault is not with the tool, but with the users. A hammer in the hands of a carpenter is a very constructive tool, whereas in the hands of a child it become a tool of destruction.

Timestudy with performance rating has experienced a fair measure of success, if you are willing to consider a tolerable situation, success. The cost in terms of employee relations and good will has frequently been excessive, and unnecessarily so. *Until Timestudy Engineers succeed in bringing performance rating down to a tangible, visible yardstick in place of the mental picture concept, disputes in workloads and production quotas will continue to disrupt industry.* For those whose sights are set on a higher goal, I offer this new slant on performance rating, not as a new system, but as an intensified approach to a difficult problem. Let us stop searching for an easy way to an infallible reputation, and concentrate all of our abilities on really learning our job of work management.

The first step is to place the horse before the cart, by taking the emphasis off performance rating. Many years spent in teaching and training in timestudy have convinced me that *performance rating cannot be taught; it results as a natural by-product of good, keen observation.* Therefore, the training emphasis should be on sharpening the powers of observation and developing a timestudy that will accurately record the detailed observations. Let us bear in mind that the main purpose of this training is to provide the background for studying all operations, especially those outside of the range of the highly repetitive operations.

It is necessary to radically depart from some of the generally accepted practices in timestudy. The following represent the essential departures:

A. USE CONTINUOUS-READING METHOD

The most important reason for using this method, oddly enough, is the very reason many engineers do not use it, namely: the observer does not and should not know the elapsed time of each recording. This is essential for two main reasons:

1. The elemental time should not in any way influence the observer's judgment of the performance.

2. It should not be necessary for trends in the recordings to alert the observer to any peculiarities in the study.

There are some who contend that having a complete view of all readings helps the observer to formulate a more accurate judgment of the performance. This is a ridiculous contention and a radical departure from the mental concept of normal performance. The relationship of any group of cold figures can provide no solid basis for judgment, but can lead only to speculation and suppositions, both of which are shaky foundations in any presentation of facts. As for alerting the observer to any peculiarities in the study, I prefer that the observer be trained to recognize the peculiarities as they occur.

The snapback method invites careless timestudy practices because there are no means of check control. It permits the luxury of relaxation during a study because the constant challenge is lacking. There is too much complacency in the belief that the timestudy field is inhabited by superconscientious individuals who require no checking or stimulation. The pattern of the exceptional individual has become the general rule. It is this letdown that results in many inequities that never appear on the timestudies. Nothing is more dangerous than a timestudy that in every respect looks good, and yet because of omissions, is actually a drastic misrepresentation of the true condition. The snapback method provides too many opportunities for such occurrences.

B. BREAKDOWN INTO ELEMENTS OF APPROXIMATELY .20 MINUTE

It is essential that the observer have ample time to observe the operation. Each recording must be preceded by a keen appraisal of the motions and their effective results. If the operation is new to the observer's experience, he would have to take one or more practice studies without rating, in order to memorize the necessary motions in each element. In the more complicated operations, the practice studies serve as a background for exploring the objectives of the operation, either with the operators, supervision, or both, so that the manner of attaining the objectives can be evaluated. There are some who insist that the engineer does not require full knowledge of an operation in order to accurately evaluate operator performance. This may make good sales talk, but it is not good timestudy practice.

C. OBSERVER MUST ACCOUNT FOR ALL VARIATIONS IN THE ELEMENTAL TIMES

Variations in the elemental time for any given element have many causes. The observer is not permitted to assume that variations are due to lower performance or a change in method. With complete knowledge of either the motions or the objectives of the element, the observer can recognize any deviations from the regular pattern of motions, resulting in variations in the elemental time. A code letter is recorded beside the reading to identify the deviation. Coded readings have been the source of a great deal of valuable information, such as:

1. Variations in the operation created by a previous operation, which can only be eliminated by correction in the preceding operation.

2. Legitimate variations in the operation due to the nature of the equipment, material, or object. If the variation is sufficiently important, attention is directed to improve the process. The extent of the variation determines the amount of study required to establish an equitable frequency of occurrence.

3. Faulty practices by the operator, either intentional or unintentional, are part of the timestudy record. If the practices are judged to be intentional, the study provides adequate information for any possible poor showing; if unintentional, the operator may be informed of the practice so that correction can be made.

D. APPLY A RATING TO EACH READING

This can only be done if the elemental breakdown provides readings of sufficient length to permit an accurate evaluation of effort. *Rating each reading without knowing the elapsed time represents a challenge to the observer's ability, which many engineers are reluctant to accept.* The contention is: why fly blindly? The pilot of a plane must attempt blind landings in order to test the accuracy of his instruments and his ability to read them correctly. In the same manner, the engineer must continually test his judgment. Any relaxation to the tests is bound to result in inconsistencies. Failure to meet the challenge, results in buried mistakes that rise to plague the offender. Infallibility can never be our lot. Yet our record can be excellent if we work on the premise that every mistake uncovered and corrected before final commitment, represents a mistake that was never made. It is thereby possible to proclaim a record of infallible results without claiming infallibility.

E. NO DECISIONS ON LEGITIMACY OF METHOD SHOULD BE MADE DURING THE TIMESTUDY

It is a contradiction to require an engineer to rate an operation objectively with a minimum knowledge of the operation, and yet grant that engineer the authority to make snap decisions on the legitimacy of method. Quite frequently, the engineer lacks sufficient knowledge of the operation to properly make these snap decisions. Since these decisions mainly result in unidentified omissions, any possible errors in judgment would be hidden in the timestudies. The studies seldom show the snap decisions that have been made, and therefore fail to show the mistakes in judgment that potentially exist. It is therefore essential that any deviations from the proper method of operation should be record-

ed with a code to permit proper identification of the occurrence. This permits adequate analysis of the occurrence and affords opportunity for consultation with supervision, if necessary, to arrive at an equitable decision.

To summarize the new approach, the most drastic change is from objective study to detailed observation of the motions performed by the operator. Before an accurate appraisal of performance can be made, it is necessary for the engineer to either memorize all of the proper motions of the entire operation, or for lengthier operations, learn all of the objectives of the operation. In order to allow ample time for observation, element times should range from .20 to .40 minute. The study should be recorded with the continuous-reading method, and a rating applied to each reading. Any deviations from the regular motions of the operation must be noted with the respective readings and rated on the premise that the deviation is legitimate. The final result is a complete story of the activity within the study correlated to an appraisal of the performance; it will disclose the alertness of the observer and the consistency of his judgment.

Each operation requires an individual search for the factors that control its performance. In the process of learning the motions of each operation, the engineer determines the effective speed required to perform that operation. The result is based upon visible factors. In effect, this means that there is no universal norm for all operations, but that each operation has its own effective speed, and therefore its own norm based upon the factors that control the operation. It is in the analysis and evaluation of these controlling factors that the operational norm is derived. This basis provides more factual information than any analysis of bare figures.

Most timestudy difficulties can be attributed to ignorance: The operator knows too little about timestudy, and the timestudy engineer knows too little about the operation. This approach helps to overcome that difficulty by forcing the engineer to learn the details of the operation. Our experience has shown that when an operation has been completely studied, the engineer will know more about the execution of that operation than anyone in the plant. If this statement is not true, the engineer has not done a good job, and there is a good possibility that the timestudy data is inaccurate or incomplete. The burden of proof of the accuracy of any timestudy must rest squarely on the shoulders of the engineer. The proof must be in the form of indisputable facts, not speculations and suppositions. Any timestudy result that cannot be proven beyond any shadow of doubt, must be wrong! This is the challenge that each engineer must meet!

(Continued on Page 23)

operations research

- *background*
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Sequence Analysis for Functional Layouts

By Elwood S. Buffa,*

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The location of the various work centers, or departments, in relation to each other is one of the most significant problems of developing a rational functional layout. The determination of the relative location of the departments is of great importance because these relationships form the basis for developing a layout plan for economical manufacture. If this phase of developing the design is done poorly, no amount of attention to the details of the layout will compensate for the fact that the work centers are improperly related to each other.

The key to strategic location for any given work center lies in the magnitude of relationships of that work center with every other work center. The relationships in this case are represented by the magnitude of the material handling problem between the given work center and every other work center. An optimal location for the work center would then be one where it is adjacent to every other center with which it has material handling relationships, either receipt from or delivery to. In the past this has been accomplished well for the major relationships, i.e., through analysis of flow of major parts which accounted for a large part of the material handling effort, it was found advantageous to locate certain departments adjacent to each other. This approach does not lend itself to an overview of all interrelationships, however, for after a few flow lines have been placed on the layout drawing it becomes a tangled mass of lines. In addition, the study of overall flow, too often took place after the project had developed to a stage where any major changes in department location would mean practically starting all over again. It is felt that the method of "Sequence Analysis" outlined below offers a sounder approach to the problem which will insure the development of near optimal relative locations of work centers or departments.

The name, "Sequence Analysis" comes from the fact that the method is based upon an analysis of the sequence of operations. The basic data of "Sequence Analysis" are therefore route sheets or operation sheets together with forecast data on the production of parts and data on the unit handling loads for parts.

Sequence Summary[1]

The first step in the analysis is the development of the Sequence Summary. (Figure 1). The data here comes from route sheets. The various departments or work centers are listed and assigned a number for convenience. At this stage in the analysis all functionally separate centers should be listed, even though the number of machines and men involved in some of them are too small to serve as a practical unit for departmentalization. The analysis will later show the optimal locations for these small centers and provide a sound basis for combining them with others to provide a departmental unit of workable size.

With the work centers listed and numbered, the parts to be studied are set down as column headings. Ideally, all parts should be listed. Where the parts are too numerous, a sampling procedure may be used. The author has not developed such a sampling procedure, but it seems that it should recognize that our desire is to sample material handling effort rather than parts.

With the work centers listed and numbered in the left column and the parts heading the various columns (see Figure 1) the analysis can be started. From the route sheet the sequence of processing is indicated. In addition certain other sequence data must be added, i.e., raw material received, sent to stores and thence to the first operation. With all of this data at hand, the Sequence Summary indicates for each part where the part goes next from where it is. For example, Part A goes from Receiving (Work Center #1) to Stores (W. C. #2) as raw material. Therefore the number listed under the column for Part A and opposite Receiving is 2. This indicates that from Receiving the material moves to W. C. #2. Dropping down to W. C. #2 then, Part A goes from W. C. #2 to W. C. #3. Dropping down to W. C. #3, the part goes from W. C. #3 to W. C. #5. In each case then, the numbers indicate the next work center by number to which the part goes.

Other data is listed in Figure 1. The production and handling data indicates the monthly production and the unit handling loads. From these data, the "Loads/mo." can be calculated, i.e. for Part A monthly production is 1000, and the unit handling load is 20: $(\frac{1000}{20} = 50$ load/mo.). Data may be known concerning unit handling loads in existing plants. If it is not available it must be determined by reference to lot size determinations, part sizes and shapes, and material handling methods. The data on "Estimated Space Required" given also in Figure 1 will be used later.

SEQUENCE SUMMARY

Work Center or Department	Part #A	Part #B	Part #C	Part #D	Part #E	Estimated Space Req'd.
Rec'g. (1)	2	2	2	2	2	500 sq. ft.
Stores (2)	3	7	3	4	3	400 " "
Saw (3)	5		4		4	200 " "
Eng. Lathe (4)			7	6	7, 7	600 " "
Turret L. (5)	7					150 " "
Drill (6)	9	9		10	4	500 " "
Mill (7)	6	8	8		8, 9	1050 " "
Grinder (8)		6	9		6	500 " "
Assy. (9)	10	10	10		10	800 " "
F. G. (10)	11	11	11	11	11	500 " "
Ship. (11)						500 " "

Production and Handling Data

Pcs./mo.	1000	2000	500	10,000	1000
Pcs./load	20	20	2	100	10
Loads/mo.	50	100	250	100	100

Figure 1. Operation Sequence Summary and summary of production and handling data. Numbers in the Sequence Summary indicate the next worker number to which the part will go.

*Vice-President, Western Region, AIIE

[1]A chart similar to this phase of the analysis is given in Ireson, W. G., **Factory Planning and Plant Layout**, Prentice-Hall, Inc., New York, 1952

SUMMARY OF LOADS PER MONTH

FROM	Rec.	Stores	Saw	Eng. Lathe	Turret Lathe	TO Drill	Mill	Grinder	Ass'y.	F.G.	Ship
Departments	1	2	3	4	5	6	7	8	9	10	11
Rec. 1		600									
Stores 2			400	100			100				
Saw 3				350	50						
Eng. Lathe						100	450				
Turret Lathe							50				
Drill 6				100					150	100	
Mill 7						50		450	100		
Grinder 8						200			250		
Ass'y. 9										500	
F. G. 10											600
Ship. 11											

Figure 2. Load summary indicates the number of loads per month between all combinations of work centers.

Load Summary

From the Sequence Summary and the data concerning the loads per month for each part, the Load Summary is developed. (Figure 2) The Load Summary indicates the number of loads per month handled between all combinations of work centers. The work centers and their number codes are listed in the left column and also across the top as headings for the other columns. The left column list is labeled "From" and the other column headings are labeled "To." From the Sequence Summary (Figure 1) all material handling occurrences are summarized for all combinations as follows: material is handled from W. C. #1 to W. C. #2 for Parts A, B, C, D, and E. Looking at the bottom line of Figure 1 this represents a total of 600 loads per month moved from W. C. #1 to W. C. #2. The number 600 is therefore entered in the appropriate space in Figure 2.

Referring back to Figure 1, the next combination of travel is from W. C. #2 to W. C. #3. This occurs for Parts A, C, and E, and represents 400 loads per month. Therefore, the figure 400 is entered in the space of the Load Summary reserved for travel "From W. C. #2 to W. C. #3." The procedure is continued until all combinations of travel between work centers are represented on the Load Summary. The result is a matrix which summarizes this critically important data. From this data the theoretical optimal relative location of work centers can be developed.

Theoretical Optimal Locations

The data developed in the Load Summary is the important data. It shows the frequency of material handling between all combinations of work centers. In order to see how they fit together, however, cut and try methods are necessary.

By arbitrarily assigning the same area to each work center, a schematic representation of the layout can be developed by placing work center numbers on a grid and assuming that any two work centers that lie adjacent to each other on the grid should physically be located adjacent to each other. Work centers that lie diagonally across from each other will also be assumed to be adjacent. (See Figure 3)

Working from the Load Summary work centers are represented as circled numbers. Lines are drawn between work centers to indicate that there is a material handling relation between them. The line is labeled with the number of loads per month to indicate the magnitude of the handling relationship. It is best to develop the schematic diagram rather than to set down all of the work centers arbitrarily and to connect the appropriate work centers with material handling lines. As the schematic diagram is developed the probability is that all work centers cannot remain adjacent to all other work centers with which they have relationships. These difficulties will have to be straightened out later by trial and error, (see Figures 3 and 4). When all relationships have been diagrammed, it will be possible to rearrange the position of the work centers so that more and more of them are adjacent to centers with which they have material handling relationships. For example, by examining Figure 3, which is the original schematic diagram resulting from the Load Summary, it is seen that if W. C. #4 is moved to a position to the left of W. C. #7 and between 2 and 6, its flow lines with 2 and 6 will be shortened without disturbing the relationships that 4 has with 3 and 7.

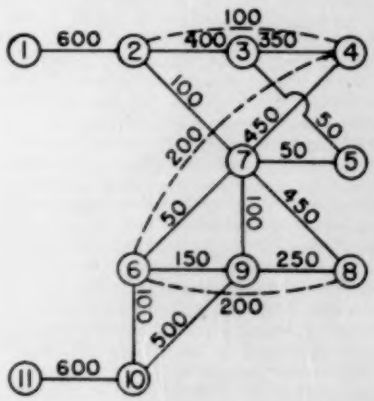

Figure 3. First schematic diagram of relative positions of work centers developed from load summary. It is seen by inspection that #4 can be moved to a more advantageous position.

If this trial and error procedure is carried out, Figure 4 results as the ideal schematic diagram representing the theoretical optimal relative locations of the work centers. It should be noted that even in Figure 4, not all work centers are adjacent to all other work centers with which they do material handling business, i.e., ideally W. C. #8 should also be adjacent to W. C. #6, but no way exists to accomplish this without creating another nonadjacent link which has greater magnitude, (number of loads per month). The Load Summary data has served also then to help make intelligent compromises, for the non-adjacent link of 200 between work centers 6 and 8 is minimum for the example given.

For highly complex problems a code system which assigns a colored line for a given range of magnitudes is useful in simplifying the trial and error procedure.

The ideal schematic diagram (Figure 4) is a step in the procedure, but it still

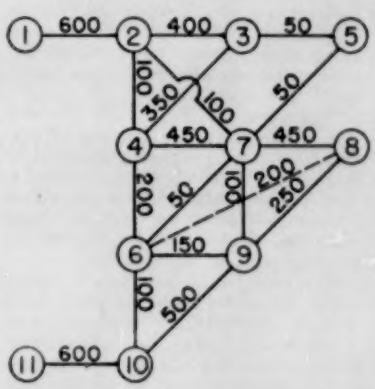

Figure 4. Ideal schematic diagram of optimal relative positions of work centers.

does not represent realistic relationships between work centers because each work center is represented only by a small circle of equal size. Of course the work centers will vary in size and this will have a bearing on the relative location of the actual work centers. To accomplish this, the Block Diagram should be developed.

The Block Diagram

From Figure 1, data is available on the estimated floor space required for each work center. This data is of course an estimate, but it should be based upon a knowledge of the number of machines required in that work center. Commonly, the actual machine areas are multiplied by a factor of 3 or 4 for an estimate of the total area required including work-

(Continued on Page 25)

The Materials Handling Function

By Dr. Eugene Richman,

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The function of materials handling has become an accepted part of Industrial Engineering.[1] Moreover, the handling of materials is generally recognized as one of the few remaining areas having spectacular cost saving potentials for industry. Yet, is much really known about materials handling?

Definitions of materials handling have appeared in numerous texts and handbooks. Many of these authoritative definitions differ considerably in their concepts. Some of these definitions are:

> Materials handling is "the lifting, shifting, and placing of any material, regardless of its size, form or weight."[2]
>
> "Materials handling is the picking up and putting down, moving of materials or products in any plane or combination of planes, by any means, which includes storage and all movements except processing operations and consumption or end use of the material."[3]
>
> "Materials handling is the preparation, placing, and positioning of materials to facilitate their movement or storage. It includes every consideration of the product except the actual processing operations and, in many instances, is included in this as an integral part of the process."[4]
>
> The objective of materials handling is "to transport materials from point to point, without retrogression, with a minimum of transfers, and deliver them to their appropriate work places or production centers in a manner to avoid congestion, delays or unnecessary handling."[5]
>
> "Materials handling is the creation of time and place utility in a material."[6]

The differences, some of which are subtle and some of which are conspicuous, may be readily detected from a close examination of these representative definitions. Despite these differences, there is considerable agreement as to what materials handling is and most industrial engineers have an intuitive knowledge of this function. Yet, there are aspects of this function which present some disturbing questions.

There are two general areas where the movement of materials is important. One area concerns the movement of all raw materials, semi-finished parts and finished goods from their place of origin to factories and warehouses, between factories, and from factories to the ultimate consumer. This form of materials handling is generally called "Transportation." The other main branch of materials handling is generally known as "Industrial Materials Handling" and is concerned only with the movement of materials within the industrial plant. This includes, of course, the shipping and receiving functions. This discussion is limited to the area of industrial materials handling only.

Even within the area of industrial materials handling there is some question as to whether a unit of material is being *transported* or *handled*. A movement of material within a plant which is essentially horizontal in displacement might be thought of as a transport, whereas a movement of material which is essentially vertical may be considered to be a handling. Transport, then, would consist of getting materials to different sections or areas of the plant, such as to a storage area, to a machine or to shipping. Handling would refer to such phases of material movement as raising or lowering into or out of storage, or to machine level or floor level. Although a pure vertical or horizontal movement is seldom encountered, it might be possible to satisfactorily determine which movements are *essentially* vertical or horizontal, in the context described. Such an arbitrary classification of materials handling into these two types might be quite useful for methods analysis or for handling equipment selection.

Another way of distinguishing between types of materials handling would be to classify them as either *transports* or *transfers* of materials. A transport would then be the movement of materials in unit loads or containers over distances of more than five feet, and a transfer would be defined as the movement of materials as individual pieces over distances of less than five feet.[7] This classification serves to emphasize the same type of difference in function as the "transport" versus "handled" classification. It avoids the determination of what is "essentially" vertical or horizontal, but substitutes the arbitrary distance of five feet as a criterion for classification.

A more basic question might be to ask where and when does materials handling take place in the factory as opposed to something other than handling occurring to a unit of material. If the material is being shaped, or fabricated, or mixed, or machined, it is ordinarily thought of as undergoing a manufacturing operation. But often, these operations occur *at the same time* as the materials or parts are being moved by conventional materials handling equipment. An instance of this might be the degreasing, spraying and baking of a formed metal part, while it is being moved through these operations by a trolley conveyor. Between stations, handling only occurs to the part, but handling also takes place during each operation. Can such an operation properly be called either a pure manufacturing operation or a pure materials handling? If not, then exactly what percentage of handling can rightfully be apportioned to the part?

Perhaps the conventional answer to this question would be to consider the entire operation a manufacturing one, and to charge all costs associated with the handling portion of this operation as part of a direct manufacturing cost. Yet, the trolley conveyor itself is certainly a typical materials handling mechanism. The use of the same conveyor solely for transport of materials would be charged as an indirect expense. A methods study resulting in a shorted conveyor length, in the one case would constitute a savings in direct cost, and in the other case in indirect cost. In the one case, the savings would be the result of improved materials handling, in the other, the manufacturing operation would have been improved.

Another cost dilemma which many concerns either are unaware of or appear satisfied to overlook is the case of the machine operator, who may be highly payed and highly skilled, who is doing materials handling as a regular part of his job. It may be that he picks up a part, positions and fastens it in his machine before proceeding to do the "skilled" part of his task. He may then perform more handling by manually removing and placing the part on a skid or on a conveyor after his operation proper is completed. The degree of handling that he does may be very small or it may be a sizeable portion of his job cycle. The important thing is that if he

[1] "At least 40 or 50 top-notch colleges give courses in materials handling and related fields," Modern Materials Handling, February, 1954. Also, Immer, J. R., **Materials Handling** McGraw, Hill, New York, 1953 p. 27.

[2] Potts, M. W., **Materials Handling Defined**, Distribution Age, April, 1951.

[3] Barker, C. H., Footlik, I. M. Yarham, C. F., and Carle, J. F., **Industrial Materials Handling**, The Lincoln Extension Institute, Cleveland, 1950.

[4] Immer, op. cit.

[5] Alford, L. P. and Bangs, J. R., **Production Handbook**, Ronald Press, 1944, p. 936.

[6] Potts, op. cit.

[7] Ireson, W. G., **Factory Planning and Plant Layout**, Prentice Hall, 1952, p. 156.

is considered a direct laborer, the handling he does is charged as a direct rather than an indirect cost. If he is paid a high rate for his skill, he may then be paid a higher than necessary rate for the handling he does. If a handler is employed to take over the handling portion of his cycle, or as much as is possible, then the portion taken over becomes an indirect expense. If a mechanical means is employed to do some or all of the handling then that portion of the work so performed, again becomes an indirect expense. This type of situation, which is not at all uncommon, reflects either an inadequacy of work assignment, or of work classification, or of accounting deficiency, or a combination of these conditions.

Still another type of merger of handling and direct manufacturing cost exists where combination, or special-purpose, or multistation types of machines are used. If work is performed on a part sequentially, on a series of presses, for example, and the part is moved by, say, gravity roller conveyors, between presses, then the conveyors are clearly units of handling equipment. The cost of movement of these parts between operations is usually considered as a materials handling cost. However, if the function of two or more presses is combined in a specially designed machine, or if a multistation type of machine such as an eyelet machine can be used for the job, then the entire series of operations taken over by the new or improved machine becomes a manufacturing operation and a direct cost, even though the parts may still be moved internally in the machine.

In the broad sense, a whole plant may be thought of as a large production mechanism, containing many moving members, some human and some mechanical, all of which function together to manipulate materials in such a way that a product is turned out. From this point of view, the percentage of materials handling as contrasted to the percentage of manufacturing that is done becomes a debatable matter.

The trend towards automation, and the use of complex transfer mechanisms and other handling devices which serve not only to automatically move parts through the plant but also to position and remove them from machines, serves even more to unite the handling and manufacturing operations. In addition to the problems of cost determination, allocation and control, there is the question of the design of the newer handling devices. Is this the province of the present materials handling equipment manufacturers or of the present production equipment manufacturers? Perhaps it is obvious that this matter vitally concerns both these groups and points out the need for ever increasing cooperation between them.

The function of storage is one which has long been associated with materials handling. The placements of goods into and the removal of goods from a storage area, by all accepted definitions, definitely is materials handling, but there seems to be some doubt about the act of storage itself. Some parts and materials are stored in separate storage areas, in various stages of completion, some are stored temporarily at machines or workplaces, still others may be stored *in motion* on conveyors, between operations, comprising so called live banks or floats. Actually, all parts, except in dead banks or cushions, where first inlast out storage is practiced, may be thought of as flowing through a storage area, if viewed over an appropriate period of time.

The determination of exactly how much materials handling is done and how it is costed is an elusive matter not only in regards to production operations, but also in the assembling and packaging areas of manufacturing.

Much handling usually occurs during packaging, oftentimes simultaneously. However, packaging has grown into such a broad and complex area, that it is rightly considered a specialized field of knowledge in itself. Still, materials handling is involved in packaging, and so, this is another place where cooperation and the interchange of information is needed.

During an assembly operation, parts may be put together completely by hand, or partly by hand and partly by machinery, or by machinery alone. Parts may move intermittently on a conveyor between assembly stations, or they may be moved in batches, or some parts may move constantly while other parts are being attached to them. Just how much materials handling takes place? Can it be said that a part is being handled whenever it is in motion? If so, is the turning of a part in an engine lathe a materials handling operation? Is it partly a materials handling operation? How much so?

Perhaps, materials handling is that handling which produces no physical change in a material but only a displacement of position. If that is so, then most assembly operations are clearly in this category. Is a power screw driver, then, a materials handling machine or a production tool?

Unless we can answer these questions we do not really know what materials handling is, and until we know exactly what it is, we cannot know how much it costs.

It is most difficult to control costs and improve profits without understanding completely what constitutes those costs, or how they may be broken down. Are materials handling cost strictly a part of factory burden or overhead as they are generally considered to be? Can materials handling equipment be economically selected without a better understanding of what materials handling is?

To summarize then, materials handling is an Industrial Engineering function. It is related to most of the areas of Industrial Engineering and is especially connected with plant layout. It is an important function and one which holds forth great promise to the Industrial Engineer. There appears to be a need for greater clarification of what is meant by materials handling. Industrial cost identification, reduction and control may be greatly benefited by such clarification. An attempt to standardize on a mutually acceptable definition would be a step in the right direction.

Materials handling is linked with and in many cases merged into manufacturing processes such as production operations, storage, assembly and packaging. There is a tendency for materials handling to blend and fade into manufacturing operations in the case of the more automated plant. This tends to decrease the importance of materials handling not because it is becoming a less vital activity, but because it becomes less significant as an isolated body of knowledge. On the other hand, the vastly increasing amounts of materials handling information and data that is rapidly accumulating is creating a need for more specialization in this area. Perhaps this dichotomy can best be solved by recognizing materials handling as a function which can be most clearly understood by a specialist, whose work *must* be coordinated with specialists in other fields working together as a team to solve the problems of plant design and operation viewed as an integrated system.

BOOK REVIEW

"The Life and Times of a Happy Liberal,"

A Biography of Morris Llewellyn Cooke, by Kenneth E. Trombley, Harper & Brothers, New York, 1954, 270 pages, $4.00

Morris L. Cooke is known to industrial engineering as the man who introduced scientific management into government when he was the Director of Public Works in Philadelphia over forty years ago. He had worked with Frederick Taylor on the re-organizing of the operations of ASME and knew personally many of the pioneers of industrial engineering. Yet for most IE's, he dropped from sight after his Philadelphia work except as co-author with Philip Murray of "Organized Labor and Production" in 1940. However, during these years, he has been active in important government and civilian posts and a strong supporter of the basic principles of scientific management with emphasis on the human factors involved.

Mr. Trombley's treatment of Cooke's activities and ideas is fresh and interesting. He relies effectively on a large measure of quotation from Cooke and others to bring the man and the engineer to life. The book is an excellent and readable biography of an important pioneer of scientific management by a competent author. We recommend it to the industrial engineeer who wants to learn more about the history and background of his profession.

—Robert M. Eastman

THE GENERALIST

By R. L. Geiger,

Comptroller, American Aluminum Co.

"An expert is anyone away from home." So runs the old saw. Today the list of fields in which there are experts runs from logistics to batting averages, from cybernetics to Doberman Pincers.

Now the evolution of a field and of an expert is clear and open. In the province of astronomy there were once star gazers, then star plotters, then mathematicians, then astro-physicists, then specialists within the various subdivisions of the cosmological field. Finally the science became a confused mass of assorted fact finders, many ignorant of what anyone else was doing. Only after a decade or two of this did the new generalists begin to make order out of this star-ridden chaos and generate new cosmologies.

The science of astronomy was selected for this analogy as it was the first of the physical sciences and has thus gone through the most evolution. Thus the analyst of other provinces of the mind may learn and profit from this long history.

Industry today is full of experts to each of whom his own pearly field, unlinked with others, is an end all and be all. The rare and unpublicized generalist, however, is the one who strings these pearls and makes a connected necklace whose whole is greater than the sum of its parts.

It is the common tendency of specialists to extend their empires and gather facts for the sake of their collection, rather than for the use to which these facts may be put. It must be remembered, of course, that our whole society is built on the collection of facts amassed by the specialists, but the synthesis of these facts into an ordered system is even more vital.

The danger is in the delegation of action to the specialists. He is not one for synthesis of seemingly unrelated wholes: to him his own field, be it machine records, human relations, production control, or statistical quality control (to mention a few from business), his own field looms so large in the foreground that it obscures the equally large contributions of the other experts.

This danger of delegation of action to the specialist can be pointedly delineated by reference to the last business field mentioned above that of Statistical Quality Control.

Here the Inspection Department has made use of the valid and original work of mathematical statisticians to formulate random plans for sampling so as to determine the attributes of the whole under consideration. But by a basic failure of the specialist millions of dollars worth of commercially good production has been delayed or rejected because of a failure to distinguish between what is not in conformity with specifications and what is not usable. An overzealous application of the technique, coupled with inadequate training of inspectors has caused the expenditure of millions of dollars for reinspection, rework and remaking of material actually usable in its present form.

Another example of the overzealousness of experts in the cancerous growth of reports spawned forth on Accounting Machines.

There is no denying the benefits obtainable by mechanized accounting and mechanized stock control. A great deal of routine clerical work has been eliminated, and posting errors minimized. Reports have been easy to obtain and within a fraction of the time necessary under hand methods. Output measured in line items has markedly increased per person.

However, there has not been a corresponding reduction in personnel. Instead there has been a flood of reports which have engulfed top management. It has become so easy to obtain a summary of statistical data that in many activities it is literally impossible to read, much less digest all the monthly reports disgorged on the executive's desk. The result is that most of them hit the dead file at the best, the circular file at the worst.

Here the blame cannot be attributed to the Machine Room Supervisor, who is harassed beyond belief, but to the various specialists within an organization. They have seized on this facility with a view to justifying their own empires hoping by the sheer weight of statistics to cement their own structures together.

"It is popular notion in some circles that the chief administrator in an agency should be an 'Expert.' This is a fallacious thesis. Generally the place for the expert is as an advisor. For what it is worth, I suggest the procedure in choosing the 'Boss' should be to choose a man with first-rate administrative ability."

Obviously it is the duty of the generalist to see beyond self-justification and to dam the stream of reports so as to produce a usable synthesis. No more should be attempted than can be used, and the old should be discarded when supplemented by the new, not retained out of habit.

Production for use, not show, should be the aim of the generalist. Long ago Occam's Razor expressed the theoretical background for an empirical approach to a problem. "Assume as little as necessary to solve a problem." This economical principle should be the guide of the executive, for a foolish multiplication of non-essentials can cloud the whole picture and make it impossible to develop it.

The generalist must take control of the system. The principle of action must be reserved to the man with the over-all viewpoint. He should suspiciously challenge any course of action recommended to him by the specialist. He must only take into consideration the benefit to the business that might be denied.

The specialized training of a generalist is all important. He must not have merely a theoretical background, but must have lived with the manifold problem of industry. The only good general is one who earns the respect of his subordinates. Likewise the good generalist must be capable of earning his place by dint of living shoulder deep in the everyday problems of business.

TIMESTUDY TRAINING AIDS

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Why Not Automatom Conformity?

By Eugene Emerson Jennings

Associate Professor of Management,
School of Business & Public Service
Michigan State College

A very interesting principle of physics is that a body gains in mass when set in motion. In human and social affairs this principle means that as people become more active they appear to be greater in number than they really are. Observation will bring forcibly before us a very simple fact which Ortega in his book entitled "The Revolt of the Masses," calls the fact of agglomeration. "Towns are full of people, houses full of tenants, hotels full of guests, trains full of travelers, cafes full of customers, parks full of promenaders, consulting rooms full of patients, theaters full of spectators, and beaches full of people. What previously was, in general, no problem, now begins to be an everyday one, namely, to find room."

Is it Room We Need?

This simple observation is impressive when we consider that this "crowding" has occurred mostly in recent years during which the population while increasing is not appreciably larger. The difference is that with more leisure and buying power people are generally more active. But Ortega in saying that the problem is to find room misses what the author believes to be a more important problem, namely, getting along with people. Human and social relations are an acute problem because of the increase in human activity, not people. And this increase in human activity has outdistanced our understanding of people and their problems. Life is no longer just one thing after another but rather one human relation after another. Any difficulty that perhaps is basically non-human or social in origin is often interpreted as such today because the trend is to be social relations conscious. Whereas economics used to be the "prime mover" of people its successor seems to be social pressure. As one writer says "money is first of all a social thing."

This is the age of the social being and his birthmark is social interaction. He must constantly relate himself to others for the threat of isolation is intolerable. Another writer says that our youth is the most group-minded we have ever had . . . when they are alone they are bored with themselves. The author was recently told by a train conductor that whereas even as late as ten years ago the parlor car would be seated by people in a strictly independent pattern. Today the traveler still chooses to sit alone but in a seat either in front or in back of one already occupied. This is the day of the social traveler.

To Break a Habit—Join a Group

In this age of the social being a social structure is being emphasized based upon group thinking, acting, decision making. Life seems for many to be a struggle to cooperate. Rather than be decisive and self-determined the ideal today in many quarters is to be influenced, pliable and subject to persuasion. Individual authority is sometimes subordinate to the authority of the group. What "they say" is more important than what a mere individual says. The group is primary and self-responsibility is now social responsibility. For example, the slogan today is that there are no juvenile children, only a juvenile society. Self discipline which Jefferson believed was the price of liberty is now social discipline. Self-control which was once admired by anyone who possessed it is now social control. Thus, recently with the advent of research into the causes of cancer many smokers have given up cigarettes. The amazing thing about this trend is that the person who decides to give up smoking often finds a friend who will also deprive himself of the habit. There is strength in the group.

Is Social Control a Fad?

One eminent social scientist recently said that our real task today is to make the individual aware of his social aspect; to nurture him in the science of social relations and thus make him a more useful citizen. And on the same day a thousand miles away another social leader said that our real task today is to make the Negro mindful of his social responsibilities. In many quarters of life today the key to progress no longer lies with individual initiators but rather with the social planners.

Why Fight—It's Bigger Than the Both of Us!

Whyte believes that more and more writers are concerning themselves with the leadership of the individual to the group and more and more resolving it in favor of the individual. The group process is revealed as bigger than any of us and thus, it is not only foolish but wrong for the individual not to reconcile himself to it. And in a similar vein Dorthea Brande who wrote the best seller, "Wake Up and Live," suggests that if the group's decision goes against you and your suggestion, abandon your own idea and cooperate in the decision wholeheartedly. One lecturer replied to a question submitted by the author, "It blunts one's thinking to speak of the participants in the social arena as individuals."

Miss Brande's statement reflects exactly what many people do today. They bring themselves into a group merely as potential to be persuaded and agreeable. One wonders why Henry Ford, who met severe opposition from his financiers to make a working man's car, did not abandon his idea. The same can be asked of Voltaire, Edison and Einstein, all of whom were strongly pressured by a group firmly convinced of their waste of effort.

Social Relations Make it Okay

In the rush, rush of social activity it perhaps is to be expected that the individual is subordinated to the group to some extent. The situation is constantly changing as it did a half century ago but then it was less changing. People mixed in close groups and worked longer hours and kept their family more intact. As a result principles of human conduct were well-established and had persisted for a number of generations. As modern science brought forth the automobile, the radio, the airplane and television such things as styles and fads became common. And as people took to the social life they found that these styles and fads came in faster and went out faster. Today the principles and norms of social conduct are in a constant state of flux and, hence, tradition and suggestions from our parents are often considered old fashioned. A new outhority is sought about how to behave and it is oftentimes found in the social life. (Whereas deciding what to wear on a date was usually a procedure that the girl members of a party went through, today the boy members call each one and find out what is fitting). While the author was teaching a class in Philadelphia he was amazed by the lack of response to his questions put to his students. After a period of time the author, who was new to their customs, asked what was the matter. Several students pointed to his suede shoes which as a midwestener were very fitting but which as a Philadelphian were worn only by hoodlums. Since no member of a fraternity could wear them in the house and if worn in public no one would speak to him, the author was given the cold shoulder.

Is Individualism Dead?

This elevating of the group substantially above the individual is herein re-

ferred to as groupism. Whereas the pendulum was for so many years stuck on the side of individualism the force required to awaken people to its falacies has persisted and created inertia which might swing the pendulum too far toward the group. One executive said "the age when a member of business can pull himself up by his own boot straps is past. We are entering a new era in which success is a group accomplishment." Another businessman recently said, "How successful you are depends on how well you have contributed to other's happiness." These statements once again are highly worthy but coming from hardheaded businessmen reflect how much the trend toward recognizing the social group has already gone. Will it go too far?

What is Individualism?

In order to answer this we need to know what is groupism. First, its opposite is individualism, which believes that the only thing that counts is the individual. Solomon Asch in his book *Social Psychology* states that only the individual can love and hate, perceive and think; he alone decides and acts. Individuals are the only real actors and term "group" is merely a convenient term for purposes of describing what individuals do. Strictly speaking, suggests Asch, as he describes the individualistic approach, there are no groups. The notion of a group becomes superfluous as soon as we have described the actions of the individuals. The individualistic approach is thus oriented toward understanding the individual, giving him responsibility, awarding him commensurate with his efforts, and solving his personal problems. To understand a social organization and how it works such as a company we must understand and know the individuals who compose it. Asch continues his description of the individualistic approach when he suggests that if we wish to understand the basis of war, we must trace it to the motive of individuals. There is nothing in the group that has not been previously in the individual.

Only the Individual Loves

Business and industry at one time practiced the individualistic approach more than it does today. The workers were treated as individuals, paid individual wages and supervised as if discrete entities. The individual was truly the sole unit that could work, think, decide and act. The individual's roots in social relations were almost completely ignored, for he could not converse with others, move around the factory to chat with others, take up a donation during working hours. The context in which the worker behaved was not pictured as primarily social. Exactly what happened to the approach requires books to describe but briefly the result was brought about by individuals combining together to exert greater control over their welfare. Group activity was resorted to because workers when treated as individuals were weak, but as members of a cohesive union were powerful, very much like two boards, which, when combined property, will support almost three times as much weight as one board.

What is Groupism?

The social aspect of the individual was brought forcibly before management and the phenomenal growth and success of the union started the pendulum on its way toward the group approach. This approach holds that people live and act not in isolation but in groups and their activity together in turn creates certain forces that are far greater than that of the individuals in the group. Sherif, in his book *An Outline of Social Psychology*, describes the group approach as forces in the group that are greater than the individuals and vastly superior so that when imposed on the member moulds him often contrary to his will. In other words, when in a group the individual no longer functions as an individual, but is somehow taken possession of by a power that dominates his behavior. As Lebon suggests in his book entitled *The Crowd*, under certain circumstances a group presents new characteristics very different from those of the individuals composing it. The sentiments and ideas of all the persons in the gathering take one and the same direction and then conscious personality vanishes. A collective mind is formed, doubtless transitory, but presenting very clearly defined characteristics. The group has become a psychological crowd. It forms a single being and is subjected to the law of the mental unity of crowds. The principal characteristics of the individual is that he is no longer himself, but has become an automaton who has ceased to be guided by his own will.

In other words there are many times when the prime mover of men is social pressure. Social pressure is basically amoral. It can be used for good just as much as for evil such as in the case of the Community Chest representative who tells the solicitee that everyone else has given, will you make it 100%. However, the attempt to establish the primacy of the group over the individual is the basic characteristic of groupism. This feature of groupism is often guised as developing harmonious human relations or fitting people together into harmonious work patterns. These are important and should be done by business and industry executives. But when done at the sacrifice of *individual initiative, individual guidance* and *respect for his autonomy* the result may be referred to as groupism.

The social relations understanding as an alternative to solution of human problems is becoming important today because contemporary technology, as distinguished from technology thirty years ago, allows the worker more to direct power rather than supply it. Thus, they have greater need and opportunity to find stimulation and enjoyment from their friends in the department and factory. Social relations in the factory are most important to the workers' happiness. Bakke found in long course of attitude study that workers think now of good or bad human relations as denial or satisfaction of their basic wants. This led Whiting Williams to write that every worker knows sooner or later that the final joy of his efforts is settled by his social standing awarded him by his fellows.

Automation does not Require Automatons

Automation, which is described by John Diebold as the Second Industrial Revolution, has promoted a group approach to management problems. It requires integrating individuals from areas of chemistry, physics, mathematics, psychology, sociology in order to equip and run an automation oriented factory. This calls for subordinating of individual's area of knowledge and integrating one's thinking with the minds of the group.

The Weakness of Departmentalization

Furthermore, because of the complexity of business and industry departmentalization of problems into economic or financial, political, social, administration is no longer as possible as it had been. Mary Parker Follett suggests that we do not have psychological, ethical and financial problems but rather we have human problems with psychological, ethical and financial aspects. The trend today is to develop capable executives who have both depth and breadth, who know the various problems associated with all the management functions and who can participate in committees assigned to the solution of a problem basically foreign to many of the members. Committee management has become very useful and has an important place in an executive's routine.

Social Scientist is no Longer in His Shell

Another reason for the growing trend toward group relations is because the social scientist who previously remained in his ivory tower in the university or college is today deeply engrossed in working with problems heretofore classified as practical and unacademic. As a result the professor is acting more and more as a consultant, either going to the factory himself or the factory going to him as is the case of the great surge of executives to seminaries, institutes and colloquiums. This transporting back and forth from the social scientists' habitat by the executives has emphasized the importance and need of the social approach.

Some Can't Hurry Enough to be Harmonious

In what manner does the activity of the executives and supervisors suggest that perhaps the trend may go too far in the direction of groupism. In many quarters a high premium is placed upon fitting people together to have a harmonious working relationship. The individual must be sensitive to the group's wishes and that this today has as paramount importance in fitting the individual to the right job. Uris, in his book

entitled *How to be a Successful Leader*, states in his preface that the way to get full cooperation is to create a harmonious working atmosphere. In Livingston's book on *Management Engineering* is stated that the basic purpose of association is to unite harmoniously more than one different activity toward a common goal and to accomplish the most with the least. Regardless of whether an association is religious, political or economical, the internal objective is always to cooperate. In many quarters this is carried too far so that what is important is the kind of behavior and attitude that makes for the harmonious function of the group.

Let's Preserve the Group at All Costs

A plant manager recently told me that he was reluctant to transfer a subordinate into another department because he might not fit in very well with the other members. He added, "I have a sweet running department there now and I don't want it broken up." His consideration was not also directed toward whether or not the individual might need the experience in the department for his own welfare and future. He was not sensitive that perhaps the individual was a problem in his present department because he wanted to go into the other department.

In another case a production superintendent remarked about an individual working for him that was not well liked at all. The author replied that that was too bad and the superintendent added that he had such a fine education and head on his shoulders that he might go someplace but for the fact that he is always disagreeing with people. This has probably been said many times and, as in this case, an individual who may have the intelligence and capacity but who does not assume certain social amenities is doomed. It is regrettable when the harmony of the group has been raised above the needs and peculiar problems of the individual.

Let's be Practical and Adjust to Reality

Currently there are many in management who have suggested that since unions are here to stay we should accept them as reality. They appear to be objective and realistic but they do not show in their thinking the possibility that if some people are dissatisfied with unions as they are now, perhaps the outcome will be a situation which is superior to that of what is reality today. Their emphasis on the law of life which is adjust or die does not take account of the fact that progress oftentimes comes out of dissatisfaction and that people who are too anxious to adjust to a given situation often find themselves adjusting from then on. Joseph Conrad's description of running all over the sea trying to get behind the weather seems typical of many people today. The author agrees that it is good that unions are here to stay. He agrees with Henry Lightfoot Nunn, President of Nunn-Bush Shoe Co. that he would not want to manage without unions. But there is nothing sacred about the structure and functions of management *nor* unions that warrants adjusting to each other's given characteristics today. A little bit of dissatisfaction often promotes seeking improvement.

Recently a committee followed the "let's not do anything more than we have to in order not to disrupt the group" approach in debating whether or not they should release some discouraging news concerning the financial position of the company. The information was never given out to the workers and only when the enterprise collapsed was the fact realized that the company had been going down hill for years.

It is encouraging to see that Studebaker Corporation recently reversed this approach and gave the workers the very discouraging news about their financial position. As things turned out the workers rallied behind the company, a gesture that won many workers over to the company's program. Just this year a major chemical company announced the decision to break up an already smoothly running organization because they believed there was nothing sacred about a group that it could not be improved. A high ranking executive told the author, "That's just it, everyone was getting along real swell. Everyone was happy and content. But you know "contented cows" are sometimes the lowest producers and the slowest thinkers. We feel that our problem is not so much to build a smoothly running team but rather develop initiative and self assumption of responsibility and these cannot be developed if the group is afraid to be disagreeable and to have an occasional spat now and then."

Just as a group can disagree without being disagreeable a group can have conflict without violence. Many superiors are coming to feel that being a "good joe" to the workers results in lower production rather than higher. It would seem that somewhere between ignoring the group and appeasing it must be found an approach to human relations.

Individual Decisions are Unstylish

The trend toward the group approach is setting in, in the area of decision making. In some cases the exception principle which allowed the executive to delegate routine duties to his subordinates in order that he concentrate on the exceptional responsibilities is now construed to mean that major decisions should be made by the group. Two heads are better than one, so many say. It is not stylish in many quarters today to make a major decision on one's own initiative and resource. Some executives cannot set alone and meditate but rather they jump at the opportunity of consulting someone. Fromm, in his book entitled *Escape From Freedom* suggests the reason for this. If a man stands on his own feet and makes individual decisions he tends to feel less closely related to other men. When he is free to make a decision he also feels isolated and his desire to belong and for close association requires that he bring others in on decisions.

Can We Think in Private as well as in a Social Situation?

An extreme example of reliance upon the apparent primacy of the group is the technique that Osborn calls brainstorming. This is a system of requiring everyone in a problem solving conference to come up with all the ideas and solutions he can think of, no matter how absurd or irrelevant, and to withhold all criticism. The slogan is "think up or shut up," which is admirable in a way but which tends to show how earnestly the group process is being relied upon to develop ideas and solutions. In one company a committee was using this approach and the author asked why such a procedure would not be as effective if the individuals would do their thinking in private. The reply from the training director was "That's just it, they wouldn't do it in private. It's no fun in isolation."

It is amazing how many members of management think they can think best only when in a social atmosphere. Another training director at a recent conference reported that if the executives do brainstorming in isolation the ideas are half as good and half as many than if they do it in a group.

The most often cited fallacy of group decision is that it is difficult to pin point responsibility. In the slogan cited that there are no juvenile children but only a juvenile society, would a judge lock up the whole town if a youth committed a crime? Similarly if a group makes a wrong decision will it hold itself responsible? Seldom does a group not blame some member and just as this is inevitable so is it necessary that the decision be made by an individual to whom the group holds responsible.

OPPORTUNITY

for

industrial

engineers

At Kennecott Copper Corporation in Utah. Must have experience in methods engineering. Apply by letter to Industrial Engineering Department, Utah Copper Division, Box 1650, Salt Lake City 10, Utah, giving details of experience and training.

But a more important fallacy of group decision occurs when the executive foregoes individual development of his own resources. If the executive reverts to the group before he had thoroughly analyzed the problems himself, two things usually happen, namely, that he soon deteriorates his own mental resources and that if everyone does this the saying that two heads are better than one is of course absurd. One very successful executive always made sure that he thought the problem through thoroughly and painfully. Until he completely exhausted his own resources, he did not resort to the group. As a result he found that he could make twice as many decisions by himself and found that when his subordinates took up the same habit, the number of committee meetings fell off drastically. On this he said, "It got so that we seldom had any committee meetings. Duties and decisions were not being done necessarily in the absence of talking to each other but consultations were more private and personal. Finally we decided we should have meetings occasionally just for social purposes. This is usually what committee meetings amounted to anyway."

The Average Man is a Straw Man

Another tendency toward an extreme use of the group approach is manifested in much of the use of survey information. The theory was once that in order to get ideas, one should survey the group but now the theory is that in order to get answers, one should survey the group. In fact Business Week introduced a special report on behavior research with the by line "To Get Answers, Ask the People." Although there is great merit in this approach groupism enters the picture when the answers given to surveys and questionnaire are relied upon solely by the executive to make decisions. The chances are his reliance is not well placed.

For example, although social problems, needs and wants of the worker and employees can be communicated, they cannot be communicated with any precision that makes infallible measurement possible. Merely because a man uses the same words or attaches the same response to a standardized set of questions does not mean that he ascribes the same values and understanding as the next man. There is no yardstick of social facts that afford an unquestionable means of description and measurement.

A survey of opinions from a group cannot measure to what extent the opinion obtained comes from individuals who do not think, can not decide, cannot interpret hearsay, are easily influenced by group opinion, can make up their minds only after both questions and answers are before them. It is not reasonable to get to a group of workers who have not critically examined their problems, needs and expect them to give intelligent answers.

An Individual Does not Necessarily Have Individual Opinions

Furthermore, before we place great faith in surveys we should get an index of each man's tendency to be easily influenced by others. Otherwise we are not obtaining opinions of individuals but merely the opinions of the one or two thinkers in the group. This may account in many surveys for the high degree of agreement in answers. As Cooley says, "All of us know that the essential things in our relation to other men are not subject to numerical measurement."

Surveys will never be a substitute for imagination, understanding and deliberate observation and these qualities, although rare in many of us will become ever rarer if the group is reverted to completely for the answers.

The last tendency that seems to manifest an extreme use of the group approach is found in group training programs and executive development procedures.

His Social I.Q. is Important

The rage today is group methods and situations in developing people. At one time the rage was entirely psychological testing of the individual but when executives realized that you cannot know a person as a living whole by a standardized test the rage was enlarged to include situational testing in which the individual was observed in social action. As one psychologist said, "We have too long been studying a man's I.Q. rather than his social I.Q."

This, together with the fact that leadership is no longer valued as a personal phenomenon, composed of a set of traits inherent in the make-up of the individual, regardless of whether he is in a social setting or not has created a need for establishing the group as a principle medium of training. Leadership is received as a social phenomenon in which one's relation to his group determines his status as a leader or a follower. This restating of leadership has created all kinds of training methods to be used on various situations. There is conference method, case study, role playing, psychodrama, forced leadership, etc. There is a method for every training problem and also a problem connected with every training method.

Social Pressure is Basic to Effective Training?

One of these problems is that there is no substitute for line training. By line training is meant that the individual superior takes a personal interest in his subordinates both as a group and as individuals. Line training is contrary to staff training, which is the common approach, in that in the latter a staff man usually called training director conducts the conferences and determines the programs. However, in line training the superior performs the duties getting advice in methods and content from the staff training officer. The lines superior is responsible for his subordinate's performance. In this way the principle of reward and punishment, in its modern interpretation, comes into play and the subordinate is held responsible to the superior for improving his proficiency.

When line training is absent the staff training officer has a very difficult time getting desirable results from his trainees. For this reason, techniques of getting group agreement and of utilizing social pressure to enforce change in behavior are currently used. These become superfluous when the line officer is responsible for training his subordinates.

In a large railroad company the public relations of the conductors were found to be pitifully poor. The railroad decided to do something about it and put on public relation training for all the conductors. The program was led by the staff members in the training department. After a year of this training the checkers on the routes could not find any substantial improvement. After considerable discussion the author counselled them on line training and thereupon they made the route superintendents (immediate superiors of the conductors) responsible for public relations and instituted a two week training program to be conducted by themselves. Almost over night the checkers revealed a substantial improvement in public relations.

The second reason why group training often fails is because the individual traineee's relations with their superiors are not coordinate with the basics of the training program. For example, the author states in *Improving Supervisory Behavior* that supervisors would not improve in their fairness to the worker because, they said, "Why should we be fair to the worker if our boss is not fair to us." So much of the training in human relations by staff members goes to waste because the situation over in the actual work place is not conducive. This problem is overcome by line training and the individual attention that comes from the supervisor. There is no substitute for the personal motivation that comes from a superior who takes a direct hand in a subordinate's training.

Are two Heads Better Than One?

In conclusion it would seem that members of business and industry are both individuals with their respective personalities and social beings with deep anchorings in the group of which they are active. The individual is both a discrete entity and a functional member of the group. At all times both his personal needs and goals as well as his social problems and relations must be carefully considered. Group decisions, surveys, incentive programs and training methods have their values but when made primary to that of individual attention, initiative, responsibility and reward, the result is comparable to automaton conformity. The price of freedom should not

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PRESIDENT'S MESSAGE

(Continued From Page 2)

upon first thought. First of all, there is a need to have a definition of the profession which defines a unique mode of analysis and area of problem solving. An approach to such a definition was suggested in the September issue of the *Journal*. Secondly, in order to provide an answer both favorable to Industrial Engineering and consistent with the above-mentioned desire to prevent the splintering tendency, it would appear necessary to define "fundamental" differently for future branches to be so included in the "fundamental" category than is apparent in the logic of the presently proposed fundamental grouping.

Consequently, it is not my purpose or hope to answer the question raised, but to present some arguments, in the form of further questions, that may be helpful in making such a determination for industrial engineering should this be desirable.

1. What problems requiring the development of engineering knowledge will face our society in the next decade or so?
2. Does study of the history of the development of engineering offer assistance in defining future "fundamental branches?"

Let me briefly discuss each of these questions.

1. Technological developments are occurring at an ever increasing rate as a result of engineering and scientific research and development over the past 15 years. Consequently, it is becoming a very real problem to introduce change as quickly and at the same time as efficiently and effectively as possible. Therefore, it would seem that one of the most important questions facing our industrial society will be *How* to select and implement from the wide variety of technological opportunities that are available. Corrolary to this is the question of *How* to most efficiently organize and control the activities of a company while at the same time introducing change and maintaining satisfactory working conditions and competitive position.

   The answer to these questions is truly an engineering problem which requires more basic methods of describing and analyzing the control systems and organization involved than are now generally employed. Solution to these problems will be challenging to the industrial engineer and should further encourage the development and generalization of engineering knowledge in the economic, humanic, and statistical areas.

   It should not be overlooked that team activity with engineers and scientists responsible for the technological developments will assume an important role. This is particularly true in the application of electronic computers to routine control problems.

   In this light it is fair to expect that industrial engineers will be called upon increasingly to develop the frontiers of engineering knowledge.
2. To many engineers it is still a somewhat revolutionary concept to consider the design of systems of men, machines, and facilities as an engineering subject. However, if it can be agreed that the *act* of utilizing scientific knowledge for the benefit of mankind is one way of defining an engineering activity, it should then follow that the determination of the most economical and satisfactory way in which the benefits of technology can be brought to humanity is *also* a responsibility of engineering.

   Some arguments can be made for the fact that the "fundamental branches" of engineering evolved and were so named largely in accordance with what may be called the principle of exclusion. Each of the branches of engineering evolved as a result of solving problems of design and prediction of cost and performance in areas "exclusive" of contemporary engineering application or as a result of utilizing new discoveries in science.

   Thus it would appear that two critera might be employed in order to determine the fundamental branches of the engineering profession. First, is the problem solving area unique, or exclusive? Second, are fundamentally different areas of scientific knowledge and methodology employed in the engineering activity? An affirmative answer to both of these questions might be required. How does industrial engineering measure up to these criteria?

In light of the challenge of the next decade as discussed above, and the new knowledge continually being made available to industrial engineers, it seems quite likely that industrial engineering may well become, if not already, a fundamental, exclusive branch of the engineering profession. Certainly the opportunity will be presented, and courageous development and expression from practitioners in this area of activity will do much to define engineering itself.

JOB DESIGN

(Continued on Page 8)

combining individual tasks into jobs. The various engineering departments such as industrial, methods, tooling and standards engineering similarly take part in specifying the content of tasks, and in all but one instance also participate in combining tasks into jobs. Approximately 25% of the time, the personnel department participates in these activities but in an advisory capacity only.

3. No systematic methods of job design can be said to exist.

4. No methods for evaluating the effectiveness of job designs can be said to exist. Determination of the effectiveness of a job design would actually consist of the application of two tests. The first test would involve checking the job design against the criteria originally used in designing to determine whether these have been satisfied. The second test would involve determining whether the desired end results, i.e., minimizing total costs of producing, has been achieved.

5. Overwhelmingly influencing the design of industrial jobs is the criterion of minimizing immediate cost of producing, i.e. immediate costs of performing the required operations. The usual indicator of achievement is minimum unit operation time. Designers of jobs see the criterion as being satisfied by the application of the following principles or guides for specifying job content:

   A. The content of individual tasks is specified.
      1. So as to achieve specialization of skills
      2. So as to minimize skill requirements
      3. So as to minimize learning time or operator training time
      4. So as to equalize and permit the assignment of a full work load
      5. In a manner which provides operator satisfaction (No specific criteria for job satisfaction were found in use)
      6. As dictated by considerations of layout of equipment or facilities, and where they exist, of the union restrictions on work assignment

   B. Individual tasks are combined into specific jobs so that:
      1. Specialization of work is achieved whenever possible by limiting the number of tasks in a job and limiting the variations in tasks or jobs
      2. The content of the job is as repetitive as possible
      3. Training time is minimized

6. As concerns the problems of achieving high productivity or high quality levels, and of minimizing employee turnover and transfers, the alteration of job content is never seen as a possible remedy for any of these problems. The literature indicates, however, that alteration of job content by means of job enlargement, etc., is used in a few scattered (numerically

TABLE 6
TRAINING REQUIREMENTS FOR INDUSTRIAL JOBS REQUIRING LOW OR MODERATE SKILL
Based on 20 Companies

Amount of Training Time Required	Per cent of Instances With Majority of Production Jobs In Classification
a. Less than one month	25
b. Between one and three months	25
c. Between three and six months	20
d. Between six months and one year	25
e. Between one and two years	5

TABLE 7
UNION AGREEMENTS LIMITING JOB ASSIGNMENT
Based on 23 Companies

Type of Limitation	Per cent of Instances
a. Job assignments are limited by union agreements to the extent that jobs under jurisdiction of one union may not be performed by a member of another union	26.1
b. Union agreements place restrictions on the tasks that can be assigned to each specific job classification for	
(1) All the industrial classifications in the company	21.7
(2) Some of the industrial classifications in the company	4.4
c. Jobs are separated by union agreement into a class for men and a class for women	17.4
d. Union agreements require promotion by seniority	13.0
e. No union agreements restricting job assignment are in effect	56.6

insignificant) instances.[4,5]

Achieving or maintaining high levels of productivity or quality are considered by a number of companies to be primarily technical matters as indicated by their approach to solving these problems through the revision of work methods, equipment, and product design. Other companies indicate that the problems could be solved through greater control over the employees using additional operator training, disciplining of operators, and more inspection of production. Some companies consider employee satisfaction to be the answer and seek to obtain it through incentive programs and employee indoctrination and education programs.

All companies having employee turnover and transfer problems believe them to be related to employee satisfaction. Two of the most frequently mentioned remedies, improved working conditions and increased pay rates, are aimed at increasing employee satisfaction. Another frequently used remedy, improved selection techniques, seeks to circumvent the problem of improving satisfaction by attempting to find employees who would be satisfied with what the company presently has to offer.

A review of the findings indicates that a great disparity exists between the ability to design effective job methods and to design job content. For the design of job methods an organized body of literature based upon experimentation and practice exists. For the design of job content no information or theories are as yet on hand and no systematic methods of job design exist. What criteria and principles the job designer does use are exceedingly narrow and directed to a very limited objective, although they do have the virtue of consistency. It is puzzling to attempt to explain why over the years so little has been done to evaluate the effectiveness of the methods of job design and of the criteria and principles upon which they rest in regard to the total cost of producing.

A question to be answered by future investigation is whether through the employment of these narrow criteria and presently used principles, the job designer obtains tasks and jobs that are organized in an effective manner in terms of minimizing the total cost of producing.

Conclusions

Based on the interview and questionnaire results, and from interpretations suggested by the results, we hypothesize the following:

1. Current job design practices are inconsistent with the principles of rationalization or scientific management. They minimize the dependence of the organization on the individual. At the same time they minimize the contribution of the individual to the work of the organization, i.e., its production process.

2. Current principles of job design reflect the mass production precepts of specialization of jobs and repetitiveness of work.

3. Job design practices minimize the effects of the individual's actions on the organization in regard to absenteeism, turnover, etc., by specifying jobs requiring short training time and having low skill requirements. Current practices also minimize the effects of "labor scarcity" whether due to high labor costs or unavailability of individuals or skills, and permit minimum hiring rates of pay.

4. Management designs jobs without systematic methods, without tested criteria, and without evaluating the effects of job designs on long-term productivity or costs. By adhering to the very narrow and limited criteria of minimizing immediate cost or maximizing immediate productivity, it designs jobs based entirely on the principles of specialization repetitiveness, low skill content and minimum impact of the worker on the production process. Management then frequently spends large sums of money and prodigious efforts on many programs that attempt to:

   a. Counteract the effects of job designs
   b. Provide satisfactions, necessarily outside the job, which the job cannot provide
   c. Build up the ego satisfaction and importance of the individual which the job has diminished

In view of the disparity of goals, the question arises as to how effective can such programs be in making employees feel that they are a significant part of an organization? Subsumed in such programs, and rightly so, is the fact that identification with the organization and its work is needed for obtaining the high motivation necessary for achieving the goals of the organization. Therefore, in view of the consequences of job design practices, ostensibly undertaken to improve efficiency, and in view of the motivational needs for improving efficiency or performance, is management following a proper course in placing continued reliance and emphasis on the narrow criterion of immediate cost? In the long run it would appear that management is placing itself in the difficult position (which some are in already) of having to force improved achievement. Since motivation cannot be relied on, management depends upon technical improvements (usually costly) for improving performance.

5. It can be concluded that company policies and practices in job design are inconsistent with programs and policies in human relations and personnel administration. On the one hand specific steps are taken to minimize the contribution of the individual and on the other hand he is propagandized about his importance and value to the organization. Does this conflict in policies and practices add to or minimize the problem of securing greater motivation?

6. Some questions that need to be raised are:

   a. From the point of view of the designer of jobs, i.e. the engineer, can the designer of jobs ever hope to predict the effectiveness of a job design in terms of minimizing total costs without an understanding and evaluation of all the variables operating?
   b. From the point of view of increasing motivation, can any human relations program or any other program undertaken to increase motivation and so productivity hope to succeed which does not begin with soundly conceived job designs based upon efficient criteria?

[4]Walker, C. R., "The Problem of the Repetitive Job," **Harvard Business Review**, May 1950, Vol. 28, No. 3, p. 54.

[5]Tangerman, E. J., "Every Man His Own Inspector, Every Foreman His Own Boss at Graflex," **American Machinist**, 1953, Vol. 97, No. 2, p. 2.

c. From the point of view of minimizing total costs of producing, can the designer of jobs achieve this goal without integrating the motivational and technical requirements of the job?

THERBLIG RELATIONSHIP

(Continued From Page 4)

For the present, industrial engineers should exercise greater care in determining the number of therbligs in a job in relation to therblig performance time as well as in relation to size of order, jig requirements, machine loading, etc. They should also be wary of any standard setting procedure which uses "universal" time for basic motions.

The analysis of variance results are listed in Table 2. The tabular values in Table 3 represent the summary of the significance of the hand motion pattern findings. The three length considerations showed strong significance. Only the difference in method means did not show significance in the area under hand pattern comparisons. As in the former analysis of variance, the interaction variances showed no indication of significance.

CONCLUSIONS

Specific conclusions may be made from the analysis of this data. These conclusions are limited by the experimental conditions.

(1) An element of work introduced in the original cycle significantly affects the original total cycle time.

(2) An element of work introduced in the original cycle significantly affects the original individual transports and dwell time at the start switch. The turning was not affected by the new element.

(3) An element of work introduced in the original cycle significantly affects the length of the hand movement.

(4) A change in work conditions of one therblig significantly affects the total cycle time.[3]

[3]These results and conclusions are an almost exact verification of the results and conclusions in Nadler, G. and Wilkes, J. W. "Studies in Relationships of Therbligs," **Advanced Management** Feb. 1953, Vol. 18, No. 2, Page 20.

Table 1
Length & Area of Hand Motion Patterns
All Measurements are Averages of Individual Hand Patterns
(As measured in terms of scaled drawings of motion path.)

Average Length Moved by Hand in 0.1 inch

	Switch 1		Switch 2		Switch 3	
	Up	Down	Up	Down	Up	Down
Method A	54.6	56.6	54.3	55.2	54.2	54.9
Method B	54.1	54.9	53.2	53.7	53.6	54.0

Average Area in Square Inches Included Under Hand Motion Pattern

	Switch 1		Switch 2		Switch 3	
	Up	Down	Up	Down	Up	Down
Method A	4.71	6.99	4.43	5.67	4.17	5.15
Method B	4.35	5.58	4.22	5.61	4.48	5.00

Table 2
Analysis of Variance Results—Time

	Variance Ratio	Tabular F	Value
	F	5%	1%
A—Total Cycle Time			
Method A and Method B	8.67	4.30	7.94
Switches 1, 2 and 3	11.67	3.44	5.72
Subjects	3.12	2.82	4.31
B—TE_3+G+RL+TE_4			
Method A and Method B	16.56	4.30	7.94
Switches 1, 2 and 3	7.32	3.44	5.72
Subjects	2.17	2.82	4.31
C—At Start Switch			
Method A and Method B	15.03	4.30	7.94
Switches 1, 2 and 3	1.78	3.44	5.72
Subjects	9.44	2.82	4.31
D—TE_3+G			
Method A and Method B	6.81	4.30	7.94
Switches 1, 2 and 3	13.36	3.44	5.72
Subjects	4.31	2.82	4.31
E—Turn Selector Switch			
Method A and Method B	.25	248.	6208.
Switches 1, 2 and 3	15.75	3.44	5.78
Subjects	2.03	2.82	4.31
F—RL and TE_4			
Method A and Method B	4.19	4.30	7.94
Switches 1, 2 and 3	5.03	3.44	5.72
Subjects	.79	5.80	14.02

Table 3
Analysis of Variance Results—Length and Area

Hand pattern mean length differences:	F	5%	1%
Method A—Method B	27.4	4.03	7.17
Switches 1, 2 and 3	9.5	3.18	5.06
Up—Down	18.5	4.03	7.17
Subjects	1.65	2.56	3.72
Hand pattern mean area differences:			
Method A—Method B	2.20	4.03	7.17
Switches 1, 2 and 3	3.75	3.18	5.06
Up—Down	36.16	4.03	7.17
Subjects	21.79	2.56	3.72

RATING

(Continued From Page 11)

The struggle to teach performance rating has been futile and ineffective, resulting in sidetracking the embryo engineer from his real task: sharpening his powers of observation. Good observation will automatically provide the true normal of performance. Detailed observations recorded on a timestudy will provide the answer to any problem arising from a production assignment. Some engineers will contend that it is not possible to record so complete a timestudy. In answer, I would quote Mr. Ketterring of General Motors, who disliked to engage men with experience to work for him because they gave too many excuses as to why jobs could not be done; he preferred new men who were too ignorant to know a job could not be done, and therefore proceeded to do it.

There will be others who will contend that what I have projected is not timestudy but motion study. The point is irrelevant. The true objective is to obtain a correct evaluation of work performed, by whatever method will achieve the most accurate result.

If timestudy imposes certain conditions that prohibit the attainment of accurate results, or confines the attainment of accurate results to a limited number of specially qualified men, it has no place in general practice. For the average timestudy engineer, the special qualities have to be developed. The present training techniques send the trainee on a headlong pursuit of the elusive norm, without direction, or the means of capturing it. Confusion and inconsistency are inevitable results!

I have firmly come to the following conclusion: the method of teaching rating was developed from the experience of highly talented men. It is presented in such form that only men with similar, natural abilities are able to grasp the elusive concept of normal. That, which is offered as training, is nothing more than tests to establish the presence or absence of these natural abilities. For the many who lack the natural abilities, this so-called training provides no solid foundation for development. Just as a true or false quiz is an excellent means of determining the degree of intelligence, it is a poor method for contributing to one's knowledge. Many intelligent engineers would be capable of a much better job of rating if their training were truly directed towards developing latent abilities.

PROGRAM

(Continued from Page 28)

SESSION D

2:00 How to Measure Fork Truck Performance

Bruno A. Moski, Director of Industrial Engineering, Yale & Towne Mfg. Co., Philadelphia, Pa.

The use of fork trucks presents a challenging materials handling work measurement problem. An extensive case study led to the development of universally applicable data. This is an excellent illustration of the use of modern techniques for setting time standards in a work area of many variables.

3:30 The Guide Chart—Profile Method of Job Evaluation

Edward N. Hay, President, Edward N. Hay & Associates, Inc., Philadelphia, Pa.

This technique affords a method of job evaluation which has been successfully applied at both management and worker levels. Among its advantages is the fact that it covers a wide range of jobs at various levels of difficulty and responsibility with a single, accurate plan.

BANQUET

Chairman: D. G. Malcolm, President, AIIE

6:30 Industrial Engineering—Now and Tomorrow

Lillian Gilbreth, President, Gilbreth, Inc., Monclair, N.J.

FRIDAY A.M.

SESSION E

9:00 A Summary of Research in Industrial Engineering—Work Simplification

Gerald E. Clark, Assist. Prof. of Indusl Engr., Wayne Univ., Detroit, Mich.

Plant Layout and Materials Handling

John R. Huffman, Dept of Engineering, Univ. of California, Los Angeles, Calif.

Time Study

Robert N. Lehrer, Prof. of Industrial Engr., Georgia Inst. of Tech., Atlanta, Ga.

Systems and Forms Analysis

Norman N. Barish, Assoc. Prof. Indusl Engr., New York University, New York, N.Y.

10:30 Analysis Techniques of Tomorrow

L. M. K. Boelter, Chairman, Dept. of Engineering, University of Calif., Los Angeles, Calif.

Although Industrial Engineers are interested in learning about new techniques which can be applied today, they must envision the future techniques and problems to better prepare themselves and their companies for the changes. Intimately associated with the industrial problem is the attempt of educators to anticipate and help develop the techniques. Engineering training and especially Industrial Engineering are experiencing many changes and the speaker will point out the trends in techniques and concepts of Industrial Engineering.

SESSION F

9:00 Statistics As a Basis for Management Decision

E. F. Gibian, Staff Director of Industrial Engineering, Thompson Products Inc., Cleveland, Ohio.

Industrial Management primarily involves the art of making decisions. Ideally these decisions are made on the basis of reliable and directly applicable information. In general, this information must be statistical in nature. The Industrial Manager must, therefore, be prepared to judge the reliability of his information and interpret its true meaning.

10:30 Union Viewpoint of Statistical Procedures in Ind. Eng.

Solomon Barkin, Director of Research, Textile Workers Union of America, C.I.O., New York, N.Y.

Statistics are being applied to analyze plant operating situations which involve and affect the working conditions and work loads of operators. Unions feel responsible for these aspects of the welfare of their members and they have investigated the validity and application of such techniques. The concepts and thoughts of Unions on this subject have been well developed by the speaker.

LUNCH

The Industrial Engineer as a Member of the Management Team

R. Conrad Cooper, Vice President, United States Steel Corp., Pittsburgh, Pa.

FRIDAY P.M.

SESSION G

2:00 Linear Programming for Production Control

M. E. Salveson, Business Procedures, Major Appliance Div., General Electric Co., Louisville, Ky.

One of the most important techniques in the area of Operations Research is Linear Programming. This provides a mathematical procedure for relating all of the problems in Production Scheduling and Control. Recent developments and applications will be presented to explain and illustrate the procedure.

LADIES' PROGRAM

May 11, 1955—Wednesday

3:00 p.m.—Anheuser-Busch Pre-Convention Social—Conferees invited.

May 12, 1955—Thursday

8:30 a.m. to 9:45 a.m.— Kaffee Klatsch.

10:00 a.m. to 1:00 p.m.— Guided tour of City, including the famed Chimpanzee Show.

1:30 p.m. to 2:30 p.m.—Luncheon Stix, Baer & Fuller Tea Room).

2:30 p.m.—Shopping.

8:30 p.m. — (Tickets available for evening activities).

May 13, 1955—Friday

9:00 a.m. to 10:00 a.m. — Coffee Hour.

10:30 a.m. to 1:00 p.m.—TV Tour and program.

4:30 p.m. to 6:00 p.m. — Cocktail Hour.

8:30 p.m.—(Tickets available for evening activities).

May 14, 1955—Saturday

9:00 a.m. to 10:30 a.m. — Kaffee Klatsch.

8:30 p.m.—(Tickets available for evening activties).

Pre-Convention Social

Members attending the American Institute of Industrial Engineers Conference and Convention in St. Louis May 12 and 13 will particularly enjoy a scheduled visit to Grant's Farm, estate of Mrs. August A. Busch and her son, August A. Busch, Jr., President of the Anheuser-Busch, Inc., St. Louis brewing firm.

Mr. and Mrs. Busch, Jr., will be hosts to the American Institute of Industrial Engineers Conference and Convention delegates at a reception planned for Wednesday afternoon, May 11. (Leaving from the Kingsway Hotel at 2:30 p.m.)

The 281-acre estate, acquired by the late August A. Busch, Sr., occupies land once farmed by Ulysses S. Grant. The cabin in which the famous President and General lived from 1854 to 1860 still stands on the grounds and is a carefully preserved historical shrine.

One of the showplaces of the Midwest, the Busch Estate has been beautifully planned and landscaped. Visitors entering through the main gate travel along a winding road past a large clear lake on which swans, ducks and geese make their home. Deer, elk, antelope, buffalo, and smaller game roam freely among the trees of the wooded land.

The Busch main house, the "little house," the Bauernhof, and other miscellaneous buildings are located on a hilltop near the center of the Estate. The Bauernhof is the heart of the building group. Modelled after European estates, it is a combination stable, garage, and barn. Here is kept the famous collection of road coaches, gigs, carts, and sleighs. The trophy room is filled with hundreds of silver cups and ribbons that Busch horses have won in shows all over the country. An ardent sportsman, Mr. Busch has perhaps the finest collection of hunting, jumping, and coach horses to be found anywhere.

Members of the American Institute of Industrial Engineers will be entertained with a tour of the Estate and a reception on the main terrace of the large family home. The terrace affords a magnificent view of the entire estate.

The Busch family has a reputation for friendly graciousness. and visitors from all over the world have enjoyed their famous hospitality at Grant's Farm. It is the sincere wish of Mr. and Mrs. Busch that all delegates at the convention will accept their invitation to visit them and attend the reception on Wednesday, May 11, 1955.

"Industrial Management,"
fifth edition, by Spriegel and Lansburgh, New York, John Wiley & Sons, Inc., 1955, $7.00

In this widely used text, the operation of an industrial concern is discussed in terms of its function and their relation to the rest of the organization. The illustration and examples are profuse and chosen well, so that the usual wordy abstraction of similar books is missing.

Reviewed by R. M. Eastman

SEQUENCE ANALYSIS

(Continued From Page 13)

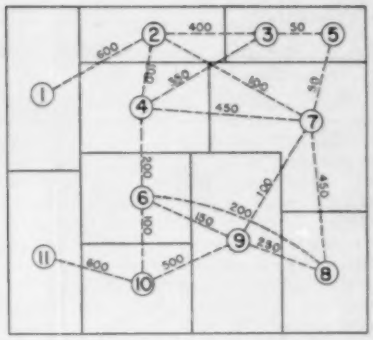

Figure 5. Block diagram resulting from the substitution of estimated work center areas for circles.

ing space for the operator, material storage and pro-rata aisle space.

The Block Diagram (Figure 5) is developed by substituting the estimated areas for the small circles of the schematic diagram. This will require more trial and error manipulation. By using rectangular paper templates to scale for the different areas and by shifting them deftly, a reasonable Block Diagram can be developed quite easily. Changes in shape for some of the blocks will be necessary in order to get the final diagram to conform to the usual rectangular shape of factory building floor plans, and/or restrictions of existing real estate of buildings.

It is probable that additional compromises in location will be made to accommodate a practical Block Diagram. However, the resulting diagram is based upon the best known ideal schematic diagram and the practical result should be an excellent solution to the actual location of work centers. At this point combinations of work centers may be made for practical departmentalization. This phase may be based upon work center sizes and similarity of work performed, and other criteria important to the particular application.

The resulting Block Diagram is the basis for the development of the details of the layout. Aisles may be blocked in to study traffic patterns, and actual machine layout will follow based upon work methods, safety, material handling methods, etc. These details, however, will be based upon a sound overall layout of work centers designed to minimize the amount of handling. This does not mean that the material handling phase of layout is complete when "Sequence Analysis" has been completed, for a major share of the material handling effort has not been examined through "Sequence Analysis." The "pick up" and "set down" time should be minimized through careful studies of material handling methods and through methods study to eliminate material handling effort from production operations.

Summary

The method of "sequence Analysis" has been presented as a basis for the development of sound functional layouts. The example given is indeed relatively simple. Actual cases are more complex and require more trial and error effort in untangling the theoretical schematic diagram. The method is a practical one, however, even for relatively complex examples. The complexity of practical examples points toward the development of a mathematical approach to minimizing the number of non-adjacent loads from the Load Summary matrix.

The same basic technique is applicable to other problems in the design of production facilities, for example, the location of controls for complex operations, and the layout of systems of men and machines.[2]

In final summary, the steps required to develop functional layouts by "Sequence Analysis" are as follows:

Step 1 Gather basic data in the form of Route Sheets for parts, production requirements, unit handling loads, and estimated floor space requirements for work centers.

Step 2 Develop the "Sequence Summary" which summarizes for each part, which work center it goes to next. (Figure 1)

Step 3 Develop the "Load Summary" (Figure 2) from the "Sequence Summary." This summarizes the number of loads per month flowing between all combinations of work centers.

Step 4 Develop the "Ideal Schematic Diagram" (Figure 4) which shows the best relative location of work centers schematically.

Step 5 Develop the "Block Diagram" (Figure 5) which shows the resulting physical relationship of work centers and can serve as the basis for practical departmentalization.

Step 6 Develop layout details, aisles, detailed material handling methods, machine layout, etc.

[2]Chapanis, A., Garner, W. R., and Morgan, E. T., "Applied Experimental Psychology," John Wiley and Sons, Inc., New York, 1949, p. 354-363.

CONFORMITY

(Continued From Page 20)

be to sacrifice the welfare of the individual to the welfare of the group as a whole. Nor is it to emphasize harmonious human relation completely at the sacrifice of individual development and expression. It is good that the pendulum now swings in the direction of the group approach but the executive must ever be mindful that whereas there is really no such thing as an indispensible person there is also no such thing as an infallible group. The majority are not necessarily correct, fifty thousand Frenchmen can be wrong, and two heads are not necessarily better than one if they are not trained to think.

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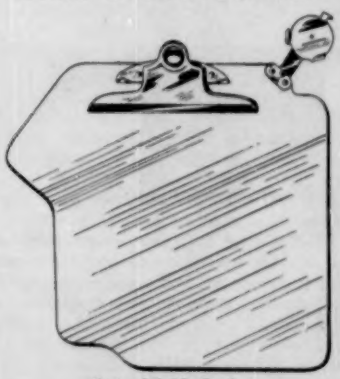

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◆ BOOK REVIEWS ◆

"Management Science,"
published quarterly by the Institute of Management Sciences

The publication of this new quarterly magazine is the result of the efforts of a nation-wide group of management analysts, social scientists, mathematicians, and engineers with a common interest in the scientific analysis of management problems.

Published under the auspices of the Institute of Management Sciences (established December 1953), the first issue features surveys of recent research on inventory control and mathematical methods in production control, an explanatory article on linear programming, and scientific papers on production and transportation scheduling.

The new journal's aim is to contribute to the theory and practice of management on the basis of new developments in the social sciences, engineering and mathematics; the intent is to give equal attention to theory and application. Scientific analysis of management problems is a currently mushrooming field due to wide interest by management in practical applications of linear programming and decision thory, plus the availability of electronic computing machines. "Management Science" may prove to be a valuable contribution to this area of research.

"Industrial Design,"
Second Edition, by Harold Van Doe Doren, McGraw-Hill Book Company, Inc., New York, 1954, 379 pages, $6.50

In this volume, Mr. Van Doren discusses the field of industrial design from the point of view of the independent design consultant. He follows through the steps of the process from preliminary research to original idea to presentation and modeling to final design. Although he devotes much of his book to professional problems, technical sales and administrative problems occupy most of the book. There are many pictures, diagrams, and case studies to illustrate the author's points. Without doubt, Van Doren's book is the most practical and useful on industrial design available to the industrial engineer today.

Reviewed by R. M. Eastman

"Managerial Statistics,"
by Kermit O. Hanson, New York; Prentice-Hall, Inc., 1955, 306 pages, $6.35

After an introduction to the basic ideas of statistics, Hanson devotes his attention to the statistical techniques used in commerce and business. He covers index numbers, time series analysis, and correlation with emphasis on their applications to business and economic data. Administrative subjects including reports and control for management and graphic presentation are also included.

—Robert M. Eastman

"The Cogwheel of Alpha Pi Mu"
Official periodical publication of Alpha Pi Mu, the Industrial Engineering Honor Society, 2889 North Hills Dr., NE, Atlanta, Georgia; subscription price is $1.00 per year for three issues per year.

With the Fall, 1954 issue, *The Cogwheel* has been revised and expanded to include articles of general interest to all industrial engineers as well as news of the society and its chapters. Among the general articles are, "Linear Programming and Industrial Engineering," by D. U. Greenwald, "Realization of Human Aspirations — a Function of Managing," by H. G. Thuesen, and a section of abstracts of Industrial Engineering articles and theses of current interest. Also, a prize-winning essay, "Should the EIT Examination Be Required for Graduation in Engineering?, by Robert L. Cline, an IE student at Oklahoma A & M, is reprinted from *The American Engineer.* The news of the biennial convention and from the chapters is well-written and interesting. Jim French, editor, executive secretary and founder of Alpha Pi Mu has done a fine job of editorship under the difficult conditions which surround any new organization.

Under its new editorial policy, *The Cogwheel* contains information and articles of interest to all industrial engineers. Much of the material and news is not available elsewhere. Although not large, this magazine is a valuable contribution to the advancement of the profession of Industrial Engineering and is worthy of our attention and suport.

Reviewed by R. M. Eastman

"Labor Productivity in Soviet and American Industry,"
by Walter Galenson. Columbia University Press, New York, 1955, 273 pages, $5.50. (A research study by the Rand Corporation.)

Professor Galenson has made an excellent and thorough analysis of available sources of data to compare labor productivity of the industrial worker in the United States and in Russia. This Comparative productivity is a vital factor in the preparation for modern, mechanized warfare and is, therefore, a matter of industrial interest to American engineers. He concludes that even though Russian productivity is rising faster than ours, the trends indicate that the present disparity will remain after many more years. Furthermore, Galenson points out that present trends may not hold in tne future and that the disparity may well grow wider or narrower. It is an interesting and able statistical analysis of the data and indices used by both countries.

Reviewed by R. M. Eastman

"Power of Words,"
by Stuart Chase, Harcourt, Brace, New York, 1954, 308 pages, $3.95

A well written popularization about an area of science is often more useful to the professionals in the field, than to the general public. Stuart Chase, with his disarmingly simple style, presents the principal findings in communication theory, linguistics, semantics, and group dynamics. He spells out their meaning, the influence these concepts have on our general thinking and the changed perspective they have given science and engineering. The industrial engineer must be equipped to evaluate and apply the many important discoveries in the whole field of information theory. The "Power of Words" offers an excellent background in the work now being done, and the extensive bibliography will allow the stimulated to go deeper into any of the twelve areas covered by Mr. Chase.

Alan J. Levy,
Bulova Watch Company

"Job Evaluation,"
Second Edition, by Jay L. Otis and Richard H. Leukart; New York, Prentice-Hall, Inc., 1954, 522 pages

In this second edition of their popular lar work, the authors have made substantial revisions and have added new material on job evaluation. Their coverage is quite complete and includes administration and related problems as well as good explanations of the job evaluation systems used in American industry and business. Except for the wage curve, there is no material on wage payment plans and other personnel topics. The authors make use of original material and have a good bibliography for further reference. The industrial engineer engaged in job evaluation work will need this volume for frequent reference.

Reviewed by R. M. Eastman

"The Case Method at the Harvard Business School,"
edited by Malcolm P. McNair, assisted by Anita C. Hersum. McGraw-Hill Book Company, Inc., New York, 1954, 292 pages, $6.50

The success and fame of the case method of instruction on the graduate level at the Harvard Business School is well known to most industrial engineers. This volume is a collection of papers by various member of the Harvard faculty on their case study methods. The uses, limitations, sources, and the role of the instructor are discussed at length. Several examples of cases and student reports are included. This is a valuable contribution to learning at the advanced level, but the discussion makes clear the limitations of the case study method at the undergraduate level.

Reviewed by R. M. Eastman

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THURSDAY A.M.

SESSION A

9:00 A.M. Travel Charts to Analyze Layout and Materials Handling Problems

L. G. Schmidt, Works Manager, Worchester Pressed Steel Company, Worchester, Mass.

Travel charting is a simple technique that enables the best flow arrangement to be developed and expressed by numbers. Optimum arrangements of a multi-item layout or complex material flow patterns can be readily determined with proper weighting of relative volume or frequency of the items. This approach leads to less materials handling better layout better manufacturing sequences and frequently more economical design of the product.

10:30 The Economics of Investing in Money Saving Improvements,

Kurt Dietz, Director of Industrial Engineering, Anheuser-Busch, Inc., St. Louis, Mo.

The Industrial Engineer is constantly faced with the problem of weighing the merit of investing in improved plant or equipment. The training of the Industrial Engineer is sometimes lacking in the necessary understanding of corporate finance and obscure costs of overhead that may turn an otherwise promising improvement into a real liability.

SESSION B

9:00—Time Study Today

Ralph Presgrave, Principal, J. D. Woods and Gordon, Ltd., Toronto, Canada.

Time Study has long been recognized as falling short of desired levels of accuracy in work measurement. Rating films, other techniques using motion pictures and pre-determined motion times have contributed to a more intimate understanding of the work measurement problem. What is the current and future status of Time Study as a basis for determining work standards

10:30 Electronics in Work Measurement

Gerald Nadler, Associate Professor of Industrial Engineering, Washington University, St. Louis, Mo.

Devices utilizing electronic principles are being designed to determine accurate and precise answers in many measurement fields. Measuring (rating) operator performance is still one of the most difficult and controversial measurement problems in engineering. The development of the UNOPAR to measure accurately velocity, acceleration, distance, time, etc., of human motions promises to give precise knowledge of basic motion activity and operator performance to help solve the rating and other motion and time study problems.

LUNCH

Adapt Yourself for Personal Progress

Edgar H. Behle, Superintendent, Men's Wear Division, Rice-Stix Inc., St. Louis, Mo.

THURSDAY P.M.

SESSION C

2:00 The Principles of Automation

John Diebold, Editor and Associate Publisher, Automatic Control Magazine, New York, N.Y.

The advantages of automation have been demonstrated by a few companies, and much has been written about the bright future for the push-button factory. However, only a few companies and engineers have an understanding of the basic components of automation. Presentation will be a discussion of the problems of handling, clamping, feed into operations, automatic inspection, automatic adjustment, etc., and the role of industrial engineers in the solution of these problems.

3:30 Use of Control Charts in Industrial Engineering

Joseph Movshin, Quality Control Manager, The Ramsey Corp., St. Louis, Mo.

Control charts are based on universal statistical concepts. They have been especially adapted to the control of product quality. However, many other areas of industrial engineering had need for similar controls, and control charts help find and sell solutions to these problems.

(Program Continued on Page 24)